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Статті друкуються англійською та українською мовами

Front page: *Aphanobasidium subnitens* (Bourdot & Galzin) Jülich on a dead log of *Pinus cembra* L., Gorgany Nature Reserve, Ukraine (see article by Bohoslavets & Prydiuk on pages 399–408 in this issue).
Photo by © Ostap Bohoslavets

На обкладинці: *Aphanobasidium subnitens* (Bourdot & Galzin) Jülich на поваленому стовбурі *Pinus cembra* L., Природний заповідник Ґорґани, Україна (див. статтю: Богославець, Придюк на стор. 399–408 у цьому номері).
Фото © Остап Богославець

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Eponyms in biological nomenclature and the Slippery Slope and Pandora's Box arguments

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Abstract. Following the discussion initiated by the opinion article by Guedes et al. (2023) "Eponyms have no place in 21st-century biological nomenclature" published in *Nature Ecology & Evolution*, in which the authors demanded to ban and cancel ***all*** eponyms (scientific names and epithets of taxa, which are derived from names of persons) in biological nomenclature, and, in particular, responding to comments by Thiele (2023) about the supposedly fallacious nature of the Slippery Slope argument (which I discussed in my earlier opinion articles), I provide here additional arguments in favor of the continued use of eponyms in particular and against politically (or so-called "ethically") motivated censorship in biological nomenclature in general. I conclude that allowing "culture wars" in biological nomenclature and possible cancellation of scientific names that are considered (or may be considered) by some people as "objectionable, offensive, or inappropriate" will result in the nomenclatural chaos caused by a large-scale disruption of well-working nomenclatural codes and naming conventions. Biological nomenclature is vitally important not only to the science of biological taxonomy but also to all other sciences and fields of human activities dealing with the living world. That nomenclature, time-proven and, indeed, sometimes loaded with complicated but also fascinating and instructive history, should not be disrupted because of ever-changing politically motivated claims and Protean vogues. It should not become a new battlefield for culture wars.

Keywords: biological nomenclature, botanical nomenclature, culture wars, eponyms, Pandora's Box argument, Slippery Slope argument, taxonomy

In his recent comment on the opinion article by Guedes et al. (2023) "Eponyms have no place in 21st-century biological nomenclature", in which the authors expressed their opinion that ***all*** eponyms (scientific names and epithets of taxa, which are derived from names of persons) should be banned and cancelled in modern biological nomenclature, Thiele (2023) mentioned the so-called Slippery Slope argument [referring to our discussion in *Taxon* (Mosyakin, 2022a, 2022b; Thiele et al., 2022, etc.)] in the following context: "…one of the principal arguments used against the proposals to deal with the most egregious eponyms is the 'slippery slope' argument — that such proposals will open a floodgate and taxonomists will necessarily need to reject all or most eponyms if they begin to reject a few [references to two articles by Mosyakin, 2022a, 2022b]". He further continued that "This fallacious argument relies on a notion that all shades of grey need to be declared either black or white and ignores the fact that societies deal successfully with shades of grey all the time".

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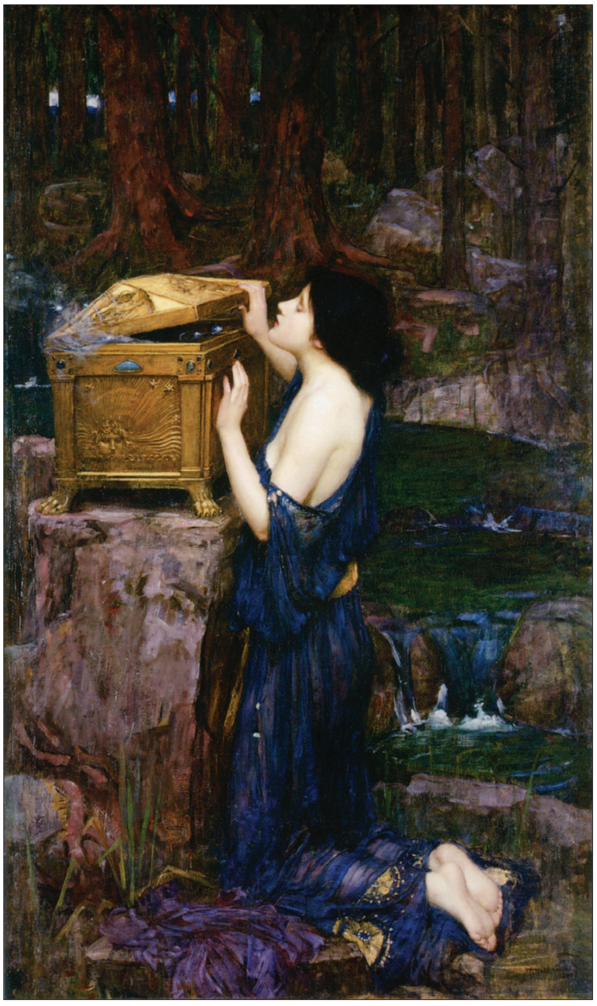

Fig. 1. *Pandora* (1896), a painting by John William Waterhouse (1849–1917), oil on canvas. Public domain (https://commons.m.wikimedia.org/wiki/File:John_William_Waterhouse_-_Pandora,_1896.jpg).

Indeed, I used the Slippery Slope argument in our earlier discussion (Mosyakin, 2022a, 2022b). Moreover, in my opinion, the article by Guedes et al. (2023), who rather unconditionally demanded the total cancellation of eponyms in biological nomenclature, and the comment by Thiele (2023), who argued that only "some, but not all, eponyms should be disallowed", clearly illustrate the Slippery Slope case, as predicted in my articles (Mosyakin, 2022a, 2022b).

Indeed, if you demand to ban and reject only ***some*** eponyms that you for some reasons dislike or find "culturally offensive" or "inappropriate" (see Hammer, Thiele, 2021; Smith, Figueiredo, 2022; Smith et al., 2022; Thiele et al., 2022), then some people will undoubtedly emerge, who will follow the suit and demand to ban and cancel ***all*** eponyms, using the same or similar categories of political, social, historical, or ethical (or "pseudo-ethical"?) arguments.

If you demand to ban eponyms referring to George Hibbert as "a promoter and beneficiary of slavery" (see Hammer, Thiele, 2021; Thiele et al., 2022), and even eponymic toponyms referring to the former country of Rhodesia (named after Cecil J. Rhodes, widely considered to be an imperialist, colonialist and racist; see Smith, Figueiredo, 2022), there will be some people who will demand to ban and cancel the eponyms (and also eponymic toponyms?) linked to Christopher Columbus (considered by some as a cruel colonialist and slave trader; see, e.g., Tinker, Freeland, 2008, and additional references in Mosyakin, 2022a), Joseph Banks (characterized by some as "an enabler of slavery" in British colonies; see references in Mosyakin, 2022b), Michel Bégon (a French colonial administrator and naturalist for whom the mega-diverse plant genus *Begonia* L. was named, but who also hoped to solve the labor shortages in American colonies of France by importing African slaves; see Rushforth, 2003: 801), Aristotle, who provided philosophical justifications of slavery and of inferiority of women, and even Carl Linnaeus and Charles Darwin, because some people believe that these two outstanding scientists held ***some*** views that are ***now*** considered racist (see further details and relevant references in Mosyakin, 2022a, 2022b).

If you demand to ban and cancel all eponyms in biological nomenclature, why should someone not demand, with equally "valid" justifications, to ban and cancel all eponyms in the nomenclature of minerals (hundreds of names, such as alexandrite, columbite, dolomite, gadolinite, goethite, perovskite, vivianite, etc.; see Senning, 2019b), chemical elements (e.g., gadolinium, curium, einsteinium, fermium, mendelevium, nobelium, lawrencium, rutherfordium, seaborgium, bohrium, meitnerium, roentgenium, copernicium, etc.; see Senning, 2019a), or astronomical objects in International Astronomical Union's nomenclature (starting with lunar craters Aristoteles, Copernicus, Fra Mauro, Humboldt, Oppenheimer, Plinius, Seleucus, Tycho, etc., and finishing with Tombaugh Regio, Hillary Montes, Tenzing Montes, and other eponymic surface features of the distant dwarf planet Pluto; see IAU, 2023–onward), or even standard SI and non-SI units (ampere, becquerel, curie, farad, joule, hertz, newton, ohm, volt, watt, etc.)?

So, this is a classical Slippery Slope and Pandora's Box (see Fig. 1) situation: your initially good intentions (with which, as the proverb says, the road to hell is sometimes paved) will be transformed into not so good consequences, and even brought *ad absurdum*. If you start culture wars in natural sciences, you will soon have eager followers (not necessarily experienced in biological taxonomy and nomenclature) who will definitely bring your good intentions to the final destination. And that destination will be the nomenclatural chaos caused by a large-scale disruption of the well-working system and naming conventions of biological nomenclature.

Definitely, that chaos will be accompanied by well-expected confrontation and even conflicts between various groups of researchers and users of scientific names of organisms, as we see already in rather hot discussions that erupted on pages of scientific journals (see, e.g., recent discussions in *Taxon* and *Nature Ecology & Evolution*: Antonelli et al., 2023; Jost et al., 2023; Mabele et al., 2023; Orr et al., 2023; Roksandic et al., 2023, etc.), popular magazines, online media, and professional online platforms, such as ResearchGate (see selected references in Mosyakin, 2022a, 2022b, 2022c). In that respect, I think that the statements by Thiele et al. (2022: 1152: "Societies everywhere manage shades of grey very well…") and Thiele (2023: "…societies deal successfully with shades of grey all the time") about the assumed ability of societies (as well as many professional communities) to deal with the ideological (or "ethical") "shades of gray" are really naïve. Most unfortunately, we see right now how "societies deal successfully with shades of grey" [sarcasm intended – SM] and how politically motivated agendas, totalitarian ideologies, cultural extremism, manipulative media technologies, and shameless propaganda are taking over whole countries and/or large strata of societies, bringing to this world the level of ideological and political confrontation unseen since the times of the Cold War or even World War II. Do we really need to open another ideological front in biological nomenclature?

Biological nomenclature (and especially its stability and predictability of its rules) is too important not only to the science of biological taxonomy but also to all other sciences and fields of human activities dealing with the living world, such as biodiversity inventory and conservation, global change ecology, agriculture, biotechnology, medicine, use and management of natural resources, international conventions and national legislation, to name just a few. Biological nomenclature (with eponyms being its large, unalienable, and important part) is vitally important for and equally open to all people representing all nations, racial, ethnic and ethnocultural groups, sexes and genders, ages, religions, political parties and views, the whole diversity of humans living on that beautiful but not so peaceful (as we currently see, e.g., in Ukraine) planet.

That nomenclature, time-proven and, indeed, sometimes loaded with complicated but also fascinating and instructive history, should not be disrupted because of ever-changing politically motivated claims and Protean vogues. It should not become a new battlefield for culture wars. It should remain the realm of peace, stability, acceptance, atonement, reconciliation, diversity, inclusivity, political neutrality, scientific freedom, meritocracy (see Abbot et al., 2023), mutual understanding and tolerance in our present-day turbulent world.

Concluding remarks: a story of the text above

The main part of the present note has been written following the discussion in *Nature Ecology & Evolution* (see Antonelli et al., 2023; Jost et al., 2023; Mabele et al., 2023; Orr et al., 2023; Roksandic et al., 2023) in response to the already mentioned opinion article by Guedes et al. (2023), in which the authors rather boldly stated that "naming species in honour of a specific person is unjustifiable and out of step with equality and representation. Reforming taxonomy to remove eponyms will not be easy [Yes, they admitted that "little obstacle"! – SM] but could [Only "could"!? Or probably could not? – SM] bring multiple benefits [not convincingly presented in the article – SM] for both conservation and society" (Guedes et al., 2023: 1157). After our preliminary exchange of email messages with editors of the journal, I pre-submitted to *Nature Ecology & Evolution* a much shorter and "softer" version of the text above, for preliminary consideration by the editors. However, the editors decided that this text is not suitable for publication in their respected journal because they have already presented "a balanced suite of views" and have drawn a line under the topic. I have accepted their decision with respect and understanding.

However, I think that this text (in its somewhat expanded and strengthened version) could be of some interest to people who follow the ongoing discussion in recent publications expressing opinions in favor of or against the politically or "ethically" motivated censorship and possible cancellation of scientific names of organisms, those names which for some reasons are considered, or just may be considered, by some people as "objectionable, offensive, or inappropriate".

I have already expressed my main arguments in several discussion articles (Mosyakin, 2022a, 2022b, 2023b) and formal proposals (Mosyakin, 2021, 2022c, 2023a, 2023c; Hayova et al., 2023, etc.) to amend the *International Code of Nomenclature for algae, fungi, and plants* (Turland et al., 2018). However, the Slippery Slope case discussed above has not yet been presented in a concise manner. Also, considering the rather high paywall separating the readers from many full texts in *Nature Ecology & Evolution*, and high publication fees of that journal, I prefer to publish my short note on the Slippery Slope case in a journal providing immediate open access to published articles. I also hope that I will be able (if time and circumstances allow) to present additional strong arguments in favor of eponyms in biological nomenclature in a larger article (now under preparation).

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Ethics Declaration

The author declares no conflict of interest.

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Епоніми в біологічній номенклатурі та аргументи "слизького схилу" і "скриньки Пандори"

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Реферат. На доповнення дискусії, розпочатої у статті "Епонімам немає місця в біологічній номенклатурі 21-го століття" (Guedes et al., 2023; опублікована у журналі *Nature Ecology & Evolution*), у якій автори вимагали заборонити та скасувати всі епоніми (наукові назви та епітети таксонів, які походять від імен осіб) у біологічній номенклатурі, а також, зокрема, у відповідь на коментарі (Thiele, 2023) про хибність аргументу "слизького схилу" (який я застосував у своїх попередніх дискусійних статтях), я наводжу тут додаткові аргументи на користь подальшого використання епонімів і проти впровадження політично (або "етично") мотивованої цензури в біологічній номенклатурі. Я вважаю, що впровадження "культурних війн" у біологічній номенклатурі та можливе скасування наукових назв, які деякі люди вважають (або можуть вважати) "небажаними, образливими чи недоречними", призведуть до номенклатурного хаосу завдяки широкомасштабному порушенню принципів та правил нормально працюючих номенклатурних кодексів. Біологічна номенклатура є життєво важливою не лише для біологічної систематики як науки, але й для всіх інших наук і галузей людської діяльності, які мають справу з живими організмами. Ця номенклатура, перевірена часом і, справді, іноді насичена суперечливою, але й водночас захоплюючою та повчальною історією, не повинна бути зруйнована на догоду мінливим політично вмотивованим концепціям та швидкоплинним вподобанням. Біологічна номенклатура та систематика не повинні стати ще одним полем битви для "культурних війн".

Ключові слова: аргумент "слизького схилу", аргумент "скриньки Пандори", біологічна номенклатура, ботанічна номенклатура, епоніми, "культурні війни", таксономія

PLANT TAXONOMY, GEOGRAPHY AND FLORISTICS
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RESEARCH ARTICLE

Leptospermum tairawhitiense (*Myrtaceae*), a new species from Aotearoa / New Zealand, segregated from *Leptospermum scoparium* s. l.

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Abstract. *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner sp. nov. (*Myrtaceae*) is segregated from *L. scoparium* J.R. Forst. & G. Forst. (sensu lato). The new species is endemic to Tairāwhiti / East Cape, Te Ika a Māui / North Island of Aotearoa / New Zealand. The new species is genetically distinct from *L. scoparium* sensu lato, *L. hoipolloi* L.M.H. Schmid & de Lange, and *L. repo* de Lange & L.M.H. Schmid, and chemically it is distinguished by having unusually high levels of triketones. Morphologically, *Leptospermum tairawhitiense* differs from these species in vegetative characters by the shortly and densely branching growth habit; the often suckering growth habit; the patent leaves, arising at 70–90° from the stem; the lamina is narrow-lanceolate, elliptic lanceolate, or rarely narrowly ovate and (3.0–)4.8–6.2(–9.0) mm long by (1.0–)1.3(–2.1) mm wide and coloured dull green to dark green, red-tinged, ± glaucescent (new growth yellow-green, red-tinged, glaucescent); and in reproductive characters, the flowers are cupped and small in comparison to other species, being 8–14 mm in diameter, with 5(–8) white petals, 5.0–7.0 × 4.6–6.4 mm and 20–32 stamens with white or pink filaments. The capsules of *Leptospermum tairawhitiense* are up to 6.8 mm wide and 5.5 mm tall when unopened, with exserted valves that comprise half the capsule height in profile, and when opened the valves exceed the capsule rim. A conservation assessment using the New Zealand Threat Classification System is proposed and a revised key to *Leptospermum* of Aotearoa / New Zealand provided.

Keywords: Aotearoa / New Zealand, *Leptospermum*, *Myrtaceae*, new species, taxonomy

Introduction

This paper is the third in a series revising the Aotearoa / New Zealand mānuka / kahikatoa (*Leptospermum scoparium* J.R. Forst. & G. Forst.) complex. The last two papers (de Lange, Schmid, 2021; Schmid et al., 2023) provided a formal treatment for three tag named entities within one of five clades recognised for *Leptospermum scoparium* s. l. by Buys et al. (2019) and Koot et al. (2022). Two

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species, *L. repo* de Lange & L.M.H. Schmid and *L. hoipolloi* L.M.H. Schmid & de Lange, were recognised, with three formae established within *L. hoipolloi*, namely f. *hoipolloi*, f. *incanum* (Cockayne) de Lange & L.M.H. Schmid and f. *procumbens* L.M.H. Schmid & de Lange (de Lange, Schmid, 2021; Schmid et al., 2023). Those papers resolved the status of *Leptospermum* aff. *scoparium* (a) (AK284541; "Auckland"), *L.* aff. *scoparium* (b) (AK247250; "coastal silver prostrate"), *Leptospermum* aff. *scoparium* (c) (AK191319; "Waikato peat bog", *Leptospermum* aff. *scoparium* (f) (AK 319498; North Cape), *Leptospermum* aff. *scoparium* (g) (AK319494; Surville Cliffs), and *Leptospermum* aff. *scoparium* var. *incanum* (h) (AK309827; North Cape), all tag named entities proposed by de Lange et al. (2018), as well as *Leptospermum scoparium* var. *incanum* Cockayne.

In this paper we examine the status of *Leptospermum* aff. *scoparium* (d) (AK286289; East Cape) which is the sole, or at least the predominant, representative of the 'East Cape North Island' cluster recognised by Koot et al. (2022) and endemic to Tairāwhiti / East Cape (Fig. 1). That entity has long been recognised on account of its distinctive chemistry (Douglas et al., 2004) and production of high yielding honey rich in dihydroxyacetone and methylglyoxal which has resulted in a thriving mānuka honey industry centred on this *Leptospermum* growing wild and in plantations at Tairāwhiti / East Cape (see https://eastcapemanuka.co.nz/). Morphologically *Leptospermum* aff. *scoparium* (d) (AK286289; East Cape) is well defined on account of its densely branched, often root suckering growth habit, resulting at times in clonal patches; its narrow, short, dark green, often red-tinged or glaucescent glabrescent leaves, that typically arise at 70–90° from the branchlet, and small, semi-campanulate flowers. On the sum of the genetic, chemical, morphological differences and because *Leptospermum* aff. *scoparium* (d) (AK286289; East Cape) is broadly sympatric and syntopic with *L. hoipolloi* and *L. scoparium,* we recognise it here as a new species *L. tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner. For ease of reading, this name will be used from here on, even before the formal description of the species.

Materials and Methods

This article is based on the study of live plants cultivated over the last one to three decades in Auckland, Hamilton, and Wellington, Te Ika a Māui / North Island, Aotearoa / New Zealand by the corresponding author. Field work to examine *Leptospermum* variation, ecology, and zones of sympatry, were undertaken from throughout the northern part of Te Ika a Māui / North Island, Tairāwhiti / East Cape, Taranaki and north-west Nelson, Te Waipounamu / South Island. Examination of fresh specimens was supplemented by study of herbarium specimens held at AK, CHR, OTA, WELT, and UNITEC (herbarium acronyms follow Thiers, 2008–continuously updated). Except for those measurements of stature and branch / branchlet widths taken from live plants in the wild, dimensions have been derived from dried material held in AK and UNITEC supplemented with some measurements taken from extremes in CHR and WELT.

Taxonomic Concept

Formal taxonomic recognition has been informed by investigations of genetic variation within New Zealand *Leptospermum* (Koot et al., 2022; Chagné et al., 2023). Insights into genetic structure from those studies have been synthesised with observational data from field work, plant collection, cultivation of wild-collected plants, and herbarium-based investigations to inform species circumscriptions that explain the distribution of character data from these data sources. Species rank has been accorded where tag name entities are widespread, sympatric, and even syntopic with accepted *Leptospermum* species, and exist as morphologically discrete and stable units (Schmid et al., 2023). Both genetic studies (Koot et al., 2022; Chagné et al., 2023) recovered a distinct genetic entity centred on the East Coast of the North Island. When plotted on linear discriminants axes, the East Coast plants form the most isolated genetic cluster among New Zealand *Leptospermum* (Chagné et al., 2023), and in dendrograms East Coast plants form a distinct cluster sister to other central North Island populations (Koot et al., 2022). In ancestry analyses East Coast plants are recovered as forming their own ancestral population, with limited evidence for admixture with geographically proximate populations (Koot et al., 2022; Chagné et al., 2023). In splits networks, however, the East Coast plants are nested among central North Island plants (Buys et al., 2019; Koot et al., 2022; Chagné et al., 2023). These patterns both are robust to data source and analysis method. With regards to *L. tairawhitiense,* the close relationships

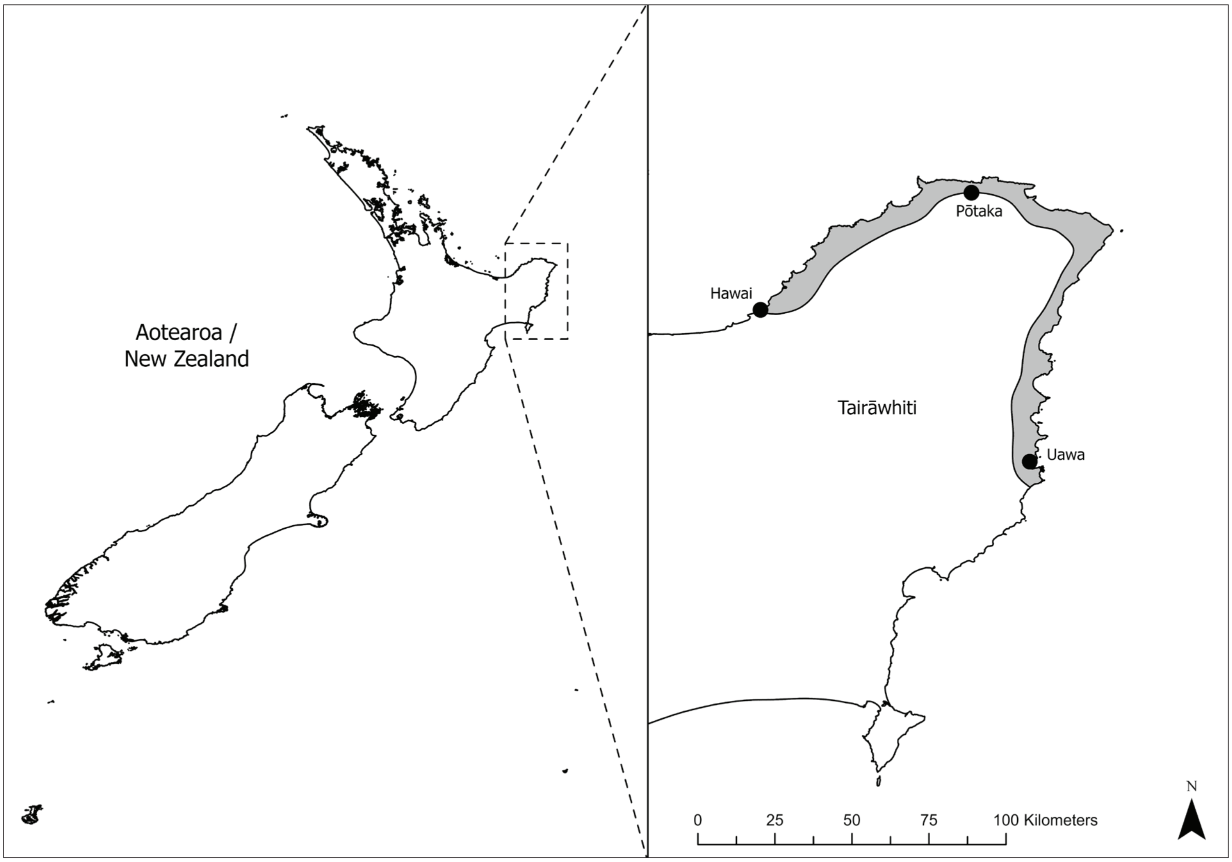

Fig. 1. Distribution of *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner in Aotearoa / New Zealand. Shaded area shows generalised distribution of *L. tairawhitiense*

with geographically proximate populations, the fact that *L. tairawhitiense* forms a discrete genetic cluster, the presence of morphological character differences, some of which are unique to *L. tairawhitiense,* ecological differences and geographic range restriction, in combination with the sympatric and even syntopic occurrence with other *Leptospermum* species, may all be explained by *L. tairawhitiense* having and maintaining a separate evolutionary identity from other *Leptospermum*. Possibly, *L. tairawhitiense* has originated via peripatric speciation from an isolated ancestral population. Genetic data obtained to date suggest limited ongoing genetic contact with other New Zealand *Leptospermum* species (Chagné et al., 2023), but this is not incompatible with the existence and maintenance of a distinct evolutionary identity for these East Coast plants (de Queiroz et al., 1998). Other interpretations are possible, but the fact remains that within the range of the Aotearoa / New Zealand endemic *Leptospermum scoparium*, distinct entities that co-habit are widespread, morphologically stable, and often biochemically distinct. Little purpose is served maintaining a single variable species, while recognising within it an informal taxonomy of distinct morpho- or chemodemes of potential economic and cultural importance (de Lange, Schmid, 2021; Douglas et al., 2004; McDonald et al., 2018; Porter, Wilkins, 1998; Porter et al., 1998; Schmid et al., 2023) that require conservation management (de Lange et al., 2018).

Taxonomy

***Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner, sp. nov.**

Type — [Figs. 2–3]: AOTEAROA / NEW ZEALAND, Te Ika a Māui / North Island, Tairāwhiti / East Cape, Anaura Bay Road, Latitude 38.294165 S, Longitude 178.303725 E, 123 m a.s.l., *P.J. de Lange 15510 & L.K.M. Fisher*, 31 Oct 2022. Abundant on regenerating slip scar above road. Holotype of two elements representing a single gathering spread over two sheets comprising adult flowering, fruiting material (AK386385A), and a sucker (AK386385B) arising from the trunk base of the same plant (AK386385A) and spreading 10–30 (or more) cm from the parent plant. Foliage fine, patent, glaucescent, reddish or dark green. Flowers often with pink stamen filaments. **Holotype:** AK386385A & B (portions from the same plant spread over two sheets); **Isotypes:** NSW, UNITEC, WELT.

Life Science Identified (LSID): urn:Isid:ipni.org:names: 77320385-1

Diagnosis: Distinguished from *Leptospermum scoparium* s. str., *L. hoipolloi* (a species with which it grows) and *L. repo* by the shortly and densely branching growth habit; the often suckering growth habit; leaves patent, arising at (70–)85–90° from the stem; lamina narrow-lanceolate, elliptic-lanceolate, rarely narrowly ovate (3.0–)4.8–6.2(–9.0) × (1.0–)1.3(–2.1) mm, coloured dull green to dark green, red-tinged, ± glaucescent (new growth yellow-green, red-tinged, glaucescent); flowers subcampanulate, 8–14 mm in diameter, with 5(–8) white petals, 5.0–7.0 × 4.6–6.4 mm and 20–32 stamens with white or pink filaments; capsules up to 6.8 × 5.5 mm (unopened), 7.2 × 4.6 mm (opened). *Leptospermum tairawhitiense* is also biochemically distinct from all other members of the *L. scoparium* complex in that it has much greater levels of triketones (up to 32.5%) in its leaves.

Growth habit (Figs. 4, 5) — erect shrubs up to 4 m tall, bases sometimes suckering, and when so forming thickets up to 2 m wide. ***Trunk*** — slender, usually unbranched at base, up to 0.2 m d.b.h., branched or not from base. ***Bark*** — usually loosely attached, chartaceous to semi-coriaceous, flaking readily, shards irregular, often with sinuous margins, adaxially charcoal grey or grey, abaxially reddish. ***Branches*** — 3 or more, erect, semi-erect or widely spreading, with numerous branchlets, young stems glabrescent, initially copiously covered in (0.10–0.22–)0.25(–0.40) mm long, white, straight to slightly flexuous, sericeous, antrorse-appressed, caducous hairs. ***Vegetative bud scales*** — 3–8, mostly shedding soon after vegetative growth commences, rarely persistent, (0.4–)0.6–0.8(–1.0) × (0.3–)0.6–0.7(–1.0) mm, amber to red-brown, scarious, oblong to ovoid, inner surface smooth, glossy, outer often entire, sometimes with frayed, lacerate margins, glabrescent. ***Leaves*** — crowded along branchlets, spicy-scented when crushed, divergent to spreading (arising at angles of (70–)85–90° from axis, in mature plants), semi-glossy yellow-green to dull dark green, usually red-tinged in seedlings, maturing, dull green to dark green, red-tinged, ±glaucescent (new growth, or if plants stressed, yellow-green, red-tinged, glaucescent); lamina (3.0–)4.8–6.2(–9.0) × (1.0–)1.3(–2.1) mm, narrow-lanceolate, elliptic-lanceolate, rarely narrowly ovate, flat to weakly concave, acute or sometimes acuminate, usually cuspidate, acumen if present up to 0.2–0.4 mm long, bases cuneate to attentuate, margins minutely denticulate; surfaces on young growth sericeous hairy either near base and along midrib, and along leaf margin, maturing glabrescent or with adaxial and abaxial surfaces sparsely covered with hairs, these (if present) either persisting on mature leaves or ± persisting on basal portion of leaf and along portions of leaf margin (especially toward base); oil glands numerous, more evident when dry. ***Perules*** — 4–6, shedding at bud burst, (0.3–)0.4–0.8 (–1.1) × (0.4–)0.6–0.8(–1.0) mm, glabrous, hyaline, amber to pale red-brown, scarious, orbicular, margins usually entire or sometimes frayed, inner surface smooth, glossy. ***Inflorescence*** — monadic on short axillary brachyblasts or on long, 400 mm long or more, terminal shoots. ***Prophylls*** — caducous, 2, 0.1–0.2 mm long, oblong, midrib scarcely developed, green to red-green when fresh, tan when dry, abaxial surface densely invested in white sericeous hairs. ***Pedicels*** — sessile or subsessile, 0.1–0.2 mm long at anthesis, sometimes elongating to 1.3 mm after anthesis, terete, sparsely invested with antrorse-appressed, sericeous white hairs. ***Flower buds*** — clavate, tholiform, spheroidal, with calyx lobes not meeting. ***Flowers*** — living flowers subcampanulate, when fully expanded (8–)10(–14) mm in diameter. ***Hypanthium*** — green, obconic, obconic-funnelform, (2.5–)3.9–4.2(–4.8) wide, by (2.2–)3.3(–4.0) mm, terminating in a thicker rim bearing five calyx lobes; surface smooth, finely glandular punctate, glabrous. ***Calyx lobes*** — 5, erect to sub-erect, 0.8–1.2 × 0.9–1.4 mm, green, broadly deltoid, subacute. ***Sepals*** — sub-erect to ± spreading, caducous, 3.0–4.5 × 3.6–4.8 mm, white, green-white, or pink-tinged, tabular-obtuse, sometimes subacute, apices often weakly cucullate, oil glands evident, colourless. Receptacle initially pink, colour intensifying to dark red at anthesis. ***Petals*** — 5(–8)5.0–6.6(–7.0) × 4.6–6.4 mm, white,

Fig. 2. Holotype of *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner (AK386385A), specimen spread over two sheets, AK386385A and AK386385B (Fig. 3)

Fig. 3. Holotype of *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner (AK386385B), specimen spread over two sheets, AK386385A (Fig. 2) and AK386385B

Fig. 4. *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner. A: Growth habit, Waipapa Stream, Tairāwhiti / East Cape, Te Ika a Māui / North Island; B: Foliage, Waipapa Stream, Tairāwhiti / East Cape, Te Ika a Māui / North Island; C: Maturing leaves, showing indumentum, which is shed at the leaves, Lottin Point, Tairāwhiti / East Cape, Te Ika a Māui; D: Mature leaves, note the angle the leaves are positioned from the branchlet axis, Lottin Point, Tairāwhiti / East Cape, Te Ika a Māui / North Island; E: Opening flower, Waipapa Stream, Tairāwhiti / East Cape, Te Ika a Māui / North Island; F: Fully opened flower with spreading petals (unusual in this species) showing pink stamen filaments, Lottin Point, Tairāwhiti / East Cape, Te Ika a Māui / North Island (all images: P.J. de Lange)

orbicular, apex obtuse, rotund, sometimes subtruncate, margins entire or finely crimped, oil glands not evident. ***Stamens*** — (20–)28(–32), arranged in 1(–2) whorls adnate to receptacular rim, filaments white or pink. Antisepalous stamens (2–)3(–4), antipetalous (2–)4–5(–6). Antisepalous stamens on filaments 1.0–1.8 mm long, incurved, erect or in mixtures of both. Antipetalous stamens erect or weakly incurved, sometimes petalloid, on filaments (3.0–)4.6–6.0 mm long, occasional inner whorl of 2 stamens present, these erect or incurved, 2.0–3.3 mm long, positioned at base of the outermost antipetalous pair. Anthers dorsifixed 0.3–0.5 × 0.12–0.16 mm, ovoid, latrorse, pink or dark red. Pollen white to cream. Anther connective gland c. 0.19 mm long, amber, or pale pink, narrowly obovoid. ***Ovary*** — 5(–7)-locular, each loculus with 70 or more ovules, set in 8 rows on each placental lobe. Style (2.6–)3.8–4.5 mm long at anthesis, elongating to 5.2 mm after anthesis, green, pink, darkening to red, at anthesis; stigma (0.40–)0.50–0.8 mm in diameter at anthesis, expanding to

Fig. 5. *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner. A: Mostly andromonoecious flowers showing subcampanulate shape, Tapuaeroa (Hikurangi Access) Road, Tapuaeroa River, Tairāwhiti / East Cape, Te Ika a Māui / North Island; B: Flowers showing subcampanulate shape, Tikapa Road, Tairāwhiti / East Cape, Te Ika a Māui / North Island; C: Mature, unopened capsule, Waipapa Stream, Tairāwhiti / East Cape, Te Ika a Māui / North Island (all images: P.J. de Lange)

1.0 mm following anthesis, flat, initially green, or pink, darkening red at anthesis, finely papillate rugulose. ***Fruits*** — persistent, woody, (4.5–)5.6(–6.8) × (3.6–)5.5 mm (unopened), (4.8–)5.8(–7.2) × (3.8–) 4.6 mm (opened), pale grey, broadly obcoic or hemispherical / globose, centre often with persistent style remnant, valves 5(–7), exserted as a dome, indented at centre, ± symmetrical with base. Valves opening on dead branches or following fire. ***Seeds*** — 2.2–2.4(–2.8) × 0.19–0.22 mm, linear, linear-cuneiform, curved, flexuous to sigmoid, laterally compressed, or terete, 2–4-angled, apex truncate or acute, testa dull or glossy, orange-brown, glabrous, longitudinally striate.

Representative specimens (out of 50 seen). Aotearoa / New Zealand, Tairāwhiti / East Cape. Pōtaka, *P.J. de Lange 15498 & L.K.M. Fisher*, 29 Oct 2022, UNITEC 13634; Lottin Point Road, *P.J. de Lange 15499 & L.K.M. Fisher*, 28 Oct 2022, UNITEC 13635; Wharekaihika, *P.J. de Lange 15500 & L.K.M. Fisher*, 29 Oct 2022, UNITEC 13636; Matakaoa Point, *P.J. de Lange 15506 & L.K.M. Fisher*, 30 Oct 2022, UNITEC 13642; East Cape Lighthouse, *G.I. Collet s.n.*, Dec 1965, CHR 183258; near Poroporo River, Tikitiki — Rangitukia Road, *P.J. de Lange 4652*, 8 Nov 2000, AK 286289; near Tikitiki, Poroporo Road, Poroporo River, *P.J. de Lange 15502 & L.K.M. Fisher*, 30 Oct 2022, UNITEC 13638; Raukūmara Range, Tapuaeroa (Hikurangi Access) Road, Tapuaeroa River, *P.J. de Lange 15503 & L.K.M. Fisher*, 30 Oct 2022, UNITEC 13639; Waiapu River, Tikapa Road, *P.J. de Lange 15504 & L.K.M. Fisher*, 30 Oct 2022, UNITEC 13640; Waiapu River, Ruatōria, Waiomatatini Road, *P.J. de Lange 15505 & L.K.M. Fisher*, 30 Oct 2022, UNITEC 13641; Ruatōria, *W.R.B. Oliver s.n.*, Nov 1926, WELT SP029275; Ruatōria, Whakaangiangi Road, *D. Grant s.n.*, Aug 1964, CHR 134301; State Highway 35, South of Ruatōria, Ahiahi Tatua, *P.J. de Lange 15507 & L.K.M. Fisher*, 31 Oct 2022, UNITEC 13643; State Highway 35, Road to Waipiro Bay, *P.J. de Lange 15508 & L.K.M. Fisher*, 31 Oct 2022, UNITEC 13644; State Highway 35, Mangahauini River, near Tokomaru Bay, *P.J. de Lange 15509 & L.K.M. Fisher*, 31 Oct 2022, UNITEC 13645; Anaura Bay, Anauru Bay Scenic Reserve, *G. Atkins EC2007*, *n.d.*, CHR 79468; State Highway 35, South of Ūawa (Tolaga Bay), Whangaroa Road, *P.J. de Lange 15511 & L.K.M. Fisher*, 31 Oct 2022, UNITEC 13646.

Etymology: The epithet "*tairawhitiense*" is taken from 'te tai rāwhiti' meaning the 'coast of the sunrise' which is the te reo Māori name for the East Cape region of Te Ika a Māui / North Island, of Aotearoa / New Zealand (Clarkson, Garnock-Jones, 1996) in which the new species is endemic. In accordance with Recommendation 60D.1 (Turland et al., 2018; Gardner, 1998) we have elected to Latinise "Tairāwhiti" to make clear that the name refers to a geographic location, and not an indigenous vernacular.

Distribution (Fig. 1): Endemic to Aotearoa / New Zealand where it is endemic to the Tairāwhiti / East Cape, occurring in a narrow band from Hawai along the coastline, river valleys, river beds and lower foothills of the Raukūmara Range, increasing in abundance from Pōtaka east and thence south along the eastern portion of Tairāwhiti / East Cape to just south of Ūawa (Tolaga Bay).

Habitats and co-associated flora species: *Leptospermum tairawhitiense* is a species of river flats, in places prone to frequent flooding, coastal shrublands and occasionally in reverting pasture on hill slopes. In these habitats it mostly associates with *Kunzea robusta* de Lange & Toelken, *Coriaria arborea* Linds. var. *arborea* and *Coprosma robusta* Raoul. On alluvium along flood prone rivers, it is often the sole woody shrub present, or the dominant one.

Phenology: *Leptospermum tairawhitiense* has one of the shortest flowering times of the Aotearoa / New Zealand species. Although sporadic flowering may be found throughout the year, peak flowering occurs in a short period of time in October and November, with occasional plants flowering into mid-December.

Affinities: *Leptospermum tairawhitiense* forms its own clade (Koot et al., 2022) and is further distinguished by its unique chemistry (Douglas et al., 2004). Plants are easily separated from other Te Ika a Māui / North Island *Leptospermum* by their short (3.0–9.0 × 1.0–2.1 mm c.f. 5.0–15.0 × 0.3–2.0 mm (in *L. repo*), 5.0–30.0 × 2.2–6.0 mm (in *L. hoipolloi*), narrowly elliptic to lanceolate, adaxially dull green to dark green, red-tinged, ±glaucescent (new growth yellow-green, red-tinged, glaucescent) leaves that arise at 70°–90° from the branchlet axis (Fig. 4B–D). Plants can vary from having seemingly leafy branchlets that obscure the branchlets (Fig. 4A) to ones that appear less leafy on account of the width of, and colouration of the leaves. Due to the disposition of the leaves, and their size and width, the flowers in this species are very conspicuous, and appear larger than they really are. Of those species in Te Ika a Māui / North Island, *Leptospermum tairawhitiense* has the smallest flower size range, 8–14 mm diameter, c.f. 10–15 mm in *L. repo* and 18–30 mm in L *hoipolloi*. Unusually for Aotearoa / New Zealand *Leptospermum,* the flowers of *L. tairawhitiense* are usually subcampanulate, rather than spreading at anthesis. Like in *Leptospermum repo,* the petals of *L. tairawhitiense* are white (Figs. 4F; 5A, B), though in common with the other species the stamen filaments may be white or pink (Figs. 4F; 5A, B), and in those with pink filaments this can give the erroneous impression that the petals are also pink-tinged. The capsules of *L. tairawhitiense* are also smaller (4.8–7.2 × 3.8–4.6 mm) than those in *L. repo* (5–9 × 5–6 mm) and *L. hoipolloi* (8.8–16.6 × 9.3–18.0 mm). *Leptospermum tairawhitiense*, unusually for the Aotearoa / New Zealand members of the genus, often but not always produces root suckers, in places forming clonal patches on the flood prone river beds, alluvial terraces and slip scars this species favours. Root suckering has also been reported in *Leptospermum scoparium* s. l. by Burrell (1965) who noted that plants which had been trampled or burnt may sucker. However, we have only seen one specimen of *Leptospermum scoparium* s. str. (OTA7221, *J.F. Burrell s.n*., 4 Mar 1963 ex Leith Saddle) exhibiting this, which was a seedling cultivated at the University of Otago. While not unique to *L. tairawhitiense,* root suckering is best developed in this species.

Throughout its range, *Leptospermum tairawhitiense* is widely sympatric and even syntopic with *L. hoipolloi* and *L. scoparium* s. str. Key differences between *L. tairawhitiense* and *L. hoipolloi* are noted above. As far as it is known, *Leptospermum repo* and *L. tairawhitiense* are wholly allopatric; no specimens of *L. repo* have been found in herbaria from the Tairāwhiti / East Cape region, presumably because the peat bog habitat *L. repo* requires is not well developed there (or it has been destroyed prior to serious botanical exploration of that region). Some specimens of *L. tairawhitiense* have leaf shapes and dimensions comparable to those in *L. repo*. However, morphologically they are readily separated (see above), have different ecological preferences, chemistry, and belong to separate clades (Koot et al., 2022).

Leptospermum scoparium s. str., as circumscribed and illustrated by de Lange & Schmid (2021; Fig. 9), morphologically differs from *L. tairawhitiense* by the broadly ovate, oval to orbicular, or broadly elliptic, ovate-elliptic leaves that are sharply acuminate ranging from 3–20 × 3.0–15 mm, rather than narrowly elliptic to lanceolate, and ranging from 3.0–9.0 × 1.0–2.1 mm. The flowers of *L. scoparium* s. str. are variable in size with some populations, notably those within the main axial mountains of Te Ika a Māui / North Island, and Te Waipounamu / South Island, having similar dimensions to *L. tairawhitiense*, though none have subcampanulate flowers (Fig. 5A, B). Otherwise, the upper size range for *L. scoparium* s. str. flowers is 24 mm diameter and 14 mm in *L. tairawhitiense*. While *L. tairawhitiense* has white petals, those of *L. scoparium* though usually white, may also be pink-tinged, pink, or even red. As noted above, root suckering, though uncommon in *L. scoparium* s. str., has been reported (Burrell, 1965). In contrast, root suckers are more commonly developed in *L. tairawhitiense*. Chemically, *L. scoparium* s. l. does not have the elevated triketone levels reported by Douglas et al. (2004) and, as currently circumscribed, belongs to different clusters: (CSNI (Central and Southern North Island), NESI (North East South Island), SWSI (South West South Island) (Koot et al., 2022). While the status of those plants referred to *L. scoparium* s. l. within those clusters still needs examination, their relationship, morphologically, chemically, and genetically, to *L. tairawhitiense* is unequivocal: they are distinct from that species.

Conservation Status: *Leptospermum tairawhitiense*, as *L.* aff. *scoparium* (d) (AK286289; East Cape), was one of several tag name entities whose conservation status was assessed by de Lange et al. (2018) following the detection of the rust *Austropuccinia psidii* (G. Winter) Beenken in Aotearoa / New Zealand in May 2017. *Austropuccinia* causes myrtle rust disease, which inflicts serious damage to the young growth, flowers and fruits of its host and will ultimately cause death (Carnegie et al., 2016). At the time the assessments for de Lange et al. (2018) were undertaken, the risk posed by *Austropuccinia* was unknown but believed to be severe. As such, the precautionary principle of Townsend et al. (2008) was invoked and all indigenous *Myrtaceae* received high threat assessments. Therefore, the panel assessed *L.* aff. *scoparium* (d) (AK 286289; East Cape) as 'Threatened / Nationally Vulnerable' qualified 'DP' [Data Poor] and 'De' [Designated] because good data on population size and trend was lacking, and because the actual threat from *Austropuccinia* was anticipated but not confirmed (de Lange et al., 2018). Since that assessment was made, there has been no evidence of myrtle rust disease in wild populations of *Leptospermum tairawhitiense*, though this species is attacked in cultivation (author's pers. obs.) so the rust remains a future threat. However, with the formal description of *L. tairawhitiense* and the apparent absence of wild occurrences of myrtle rust disease on this species, a reappraisal of the conservation status is necessary.

Leptospermum tairawhitiense is a naturally localised endemic mostly confined to the north and north-eastern portion of Tairāwhiti / East Cape. Field work during October / November 2022 noted numerous populations across this area, many in secure habitats, and others, whilst on private land, unlikely to be threatened by development due to their use for the mānuka honey and oil industry. While a confident population size estimate was not obtained, it is assumed that there are up to 20,000 mature individuals (on the assumption that not all are the result of clonal clustering) in the wild and that, at least for now, the total population is stable (if not increasing due to plantings for the honey and essential oil industry). Using these criteria, we recommend a conservation status of 'At Risk / Naturally Uncommon'. However, we still lack exact population sizes and trends, so we recommend that this assessment be qualified 'DPS' [Data Poor Population Size] and 'DPT' [Data Poor Trend] as per the revisions of (Rolfe et al., 2019). Obviously, this threat assessment will change if *Austropuccinia psidii* is found infecting wild plants.

Key to *Leptospermum* of Aotearoa / New Zealand

1. Leaves ovate, shortly oblong or orbicular (up to 20 mm long), sharply acute, or long acuminate, glabrescent .... *Leptospermum scoparium*

– Leaves, linear, linear-lanceolate, filiform, lanceolate, elliptic-lanceolate (3–30 mm long) sometimes acute or acuminate, glabrescent, or hairy .. 2

2. Leaves up to 30 × 4 mm, hairy, or glabrescent, dull to semi-glossy, red-green, green to dark green, sometimes glaucescent, lanceolate, elliptic-lanceolate. Flowers white, white streaked or tinged pink, pink or red up to 30 mm diameter (when fresh). Trees (up to 10 m tall), shrubs or decumbent with trailing, prostrate stems 3

– Leaves up to 15.0 × 1.3(−2.1) mm, glabrescent, glossy, or dull, red-green, glaucescent, yellow-green, green, or dark green. Flowers white, up to 15 mm diameter (when fresh). Trees or shrubs (up to 6 m tall) erect, either sparingly or spindly-branched or densely branched 5

3. Leaves 5.0–22.0 × 2.2–3.1 mm; lamina lanceolate to elliptic lanceolate; young and mature leaves dull to semi-glossy, usually green to dark green (sometimes glaucescent); surfaces on young leaves hairy near base and along midrib, and leaf margin, mature leaves ± glabrescent with hairs ± persisting on basal portion of leaf and along portions of leaf margin. Flowers up to 24 mm diameter when fresh. Trees (up to 10 m tall) or shrubs .... *Leptospermum hoipolloi* f. *hoipolloi*

– Leaves 5.6–30.0 mm long by 2.2–6.0 mm wide, lamina elliptic lanceolate to broadly lanceolate; young leaves silver-white, silvery-grey, or grey, mature leaves red-green, green, or dark green, mature leaves densely sericeous hairy. Flowers up to 30 mm diameter when fresh. Shrubs (up to 3 m tall) or decumbent with prostrate, trailing branches that often layer on contact with soil) 4

4. Branches decumbent, prostrate, widely spreading (often laying on contact with soil), forming circular patches. Leaves silver-white to silvery-grey, 5.6–24.0 × 2.2–3.8 mm. Flowers up to 24 mm diameter when fresh, usually white, sometimes pink-tinged, or pink. Shrubs up to 1 m tall .... *Leptospermum hoipolloi* f. *procumbens*

– Branches erect. Leaves silvery-grey or dark grey, 6.0–30.0 × 4.2–6.0 mm. Flowers up to 30 mm diameter when fresh, usually white tinged or streaked pink or pink or occasionally red. Shrubs up to 3 m tall) .... *Leptospermum hoipolloi* f. *incanum*

5. Leaves linear, linear-lanceolate, filiform, up to 15 mm long and 2 mm wide, glossy, yellow-green, green to dark green, glabrescent (new growth glossy yellow-green, bronze-green or dark green); flowers flat, staminal filaments usually white, or very rarely with pink. Trees up to 6 m tall, or shrubs, single stemmed without root suckers, confined to peat bogs .... *Leptospermum repo*

– Leaves narrow-lanceolate, elliptic lanceolate, rarely narrowly ovate, up to 9 mm long and 2 mm wide, semi-glossy or dull, dull green to dark green, red-tinged, ±glaucescent (new growth yellow-green, red-tinged, glaucescent); flowers cupped, with staminal filaments pink or white. Shrubs up to 4 m tall, often with root suckers, growing in river flats, on alluvium, slip scars or regenerating coastal vegetation .... *Leptospermum tairawhitiense*

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Ethics Declaration

The authors declare no conflict of interest.

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Leptospermum tairawhitiense (_Myrtaceae_), новий вид з Аотеароа / Нової Зеландії, виділений з групи _Leptospermum scoparium_ s. l.

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Реферат. *Leptospermum tairawhitiense* G.J. Atkins, de Lange & M.A.M. Renner sp. nov. (*Myrtaceae*) виділено з видового комплексу *L. scoparium* J.R. Forst. & G. Forst. (sensu lato). Новий вид є ендемічним для Східного мису Північного острова Аотеароа / Нової Зеландії. Новоописаний вид є генетично відмінним від *L. scoparium* sensu lato, *L. hoipolloi* L.M.H. Schmid & de Lange і *L. repo* de Lange & L.M.H. Schmid, а за хімічним складом відрізняється надзвичайно високим рівнем трикетонів. Морфологічно *Leptospermum tairawhitiense* відрізняється від цих видів за такими вегетативними ознаками: короткими і густо розгалуженими пагонами; частими кореневими пагонами; відхиленими листками, що відходять від стебла під кутом 70–90°; вузьколанцетними, еліптично-ланцетними або зрідка вузькояйцеподібними листками, (3,0–)4,8–6,2(–9,0) мм завдовжки та (1,0–)1,3(–2,1) мм завширшки, тьмяно-зеленими або темно-зеленими, з червоним відтінком, ± сизуватими (у молодої порослі — жовто-зеленими, з червоним відтінком, сизуватими); щодо генеративних ознак, новоописаний вид відрізняється чашоподібними квітками, дрібнішими у порівнянні з іншими видами, 8–14 мм у діаметрі, з 5(–8) білими пелюстками, 5,0–7,0 × 4,6–6,4 мм, і 20–32 тичинками з білими або рожевими нитками. Коробочки *Leptospermum tairawhitiense* до 6,8 мм завширшки і 5,5 мм заввишки у закритому стані, з випнутими клапанами, що складають половину висоти коробочки у профіль, а у відкритому стані виступають за край коробочки. Запропоновано оцінку природоохоронного статусу згідно з класифікацією загроз, прийнятою у Новій Зеландії, та наведено ключ для визначення видів роду *Leptospermum* Аотеароа / Нової Зеландії.

Ключові слова: *Leptospermum*, *Myrtaceae*, Аотеароа / Нова Зеландія, новий вид, таксономія

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RESEARCH ARTICLE

Some wood-inhabiting *Basidiomycota* from the primeval forests with *Pinus cembra* in Ukraine

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Abstract. The *Pinus cembra* communities belong to the rarest and least studied woody habitats in Europe. This article reports 30 species of lignicolous *Basidiomycota* revealed in primeval spruce stands with the admixture of arolla pine in Gorgany Nature Reserve (the Ukrainian Carpathians). Five species, namely *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* and *H. cremicolor*, are firstly reported in Ukraine. The records of *Cystostereum murrayi*, *Phellinus viticola* and *Pycnoporellus fulgens* deserve particular attention due to their value as bioindicators of natural forest ecosystems. The species composition of *Basidiomycota* per individual fallen log turned out to be rather poor. The fungi forming thin resupinate corticioid basidiocarps on the substrate underside prevail among the finds, indicating a lack of moisture in the surveyed treeline stands. Detailed descriptions of the substrate and collection site are given for each find. An overview of previous research on the diversity of lignicolous *Basidiomycota* in arolla pine forests is provided.

Keywords: *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *Hypochnicium cremicolor*, *Phellinus viticola*, rare species, treeline, Ukrainian Carpathians

Introduction

Communities of *Pinus cembra* L. (*Pinaceae*) are restricted to high mountain altitudes in the Alps and the Carpathians and belong to the rarest and least studied forest types in Europe (Critchfield, Little, 1966; Blada, 2008; Kučera, 2019). In the Ukrainian Carpathians, stands with arolla pine have an insular pattern of distribution, occurring as small-area disjunctive localities scattered through the upper parts of river basins of the Brusturianka, Bystrytsia Nadvirnianska, Bystrytsia Solotvynska, Limnytsia, Prut and Svicha rivers (Sirenko, 2005; Popovych et al., 2019; Cherniavskyi, 2021). Overall, these stands cover an area of around 4195 ha; of them, nearly 4160 ha are located in the Gorgany region — the least populated part of the Ukrainian Carpathians, characterized by medium elevations (up to 1836 m a.s.l.), steep slopes and the presence of large stone fields covering the upper parts of the ridges (Sirenko, 2005; Klimuk et al., 2006).

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Arolla pine populations in Ukraine are under threat due to extensive logging and replacement by the Norway spruce (*Picea abies* (L.) H. Karst.) in forest stands. For this reason, the species is included in the *Red Data Book of Ukraine* (Chervona..., 2009; https://zakon.rada.gov.ua/laws/show/z0370-21#Text).

In the *National Habitat Catalogue of Ukraine* (Kuzemko et al., 2018), the forest communities with *Pinus cembra* are referred to as "Arolla pine forests". Hence, we apply the term "arolla pine forest" to describe forests with arolla pine in the Ukrainian Carpathians, irrespective of whether this species dominates or not in the stand.

Gorgany Nature Reserve was established in 1996 to protect the best-preserved forests of the upper part of the Bystrytsia Nadvirnianska river basin. Spruce-dominated forests cover approximately 86% of the reserve area, stone fields — nearly 11%, meadows — less than 2% (Klimuk et al., 2006). The primeval spruce stands with the admixture of arolla pine are scattered through the upper part of the forest belt (965–1580 m a.s.l.) and occupy 7.1% of the total area (Cherniavskyi, 2021). In 2017, some of the most valuable stands of Gorgany Nature Reserve became a part of the "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" UNESCO Natural World Heritage Site (UNESCO, 2017).

Information about the diversity of lignicolous fungi in the arolla pine communities is scattered over a range of scientific publications (Nicolotti et al., 1999; Bernicchia et al., 2007; Küffer et al., 2008; Holec et al., 2015; Merges, 2019). In most cases, they mention either the fungi occurring on wood of *P. cembra* (*Antrodia alpina* (Litsch.) Gilb. & Ryvarden, *Athelia epiphylla* Pers. s. l., *Chromosera cyanophylla* (Fr.) Redhead, Ammirati & Norvell, *Fomitopsis pinicola* (Sw.) P. Karst., *Gloeophyllum sepiarium* (Wulfen) P. Karst., *Heterobasidion annosum* (Fr.) Bref., *Piloderma byssinum* (P. Karst.) Jülich), or wood-inhabiting species forming an ectomycorrhizal symbiosis with arolla pine (*Amphinema byssoides* (Pers.) J. Erikss., *Tomentella stuposa* (Link) Stalpers, *Tylospora asterophora* (Bonord.) Donk, *T. fibrillosa* (Burt) Donk).

Dämon (2000), however, provided lists of noteworthy corticioid species recorded in two types of the arolla pine communities of the Austrian Alps. For a stand composed of *Abies alba* Mill., *Picea abies* and *Pinus cembra*, he reported *Amylocorticium subsulphureum* (P. Karst.) Pouzar, *Cerocorticium sulfureoisabellinum* (Litsch.) Jülich & Stalpers (as *Flavophlebia sulfureoisabellina* (Litsch.) K.H. Larss. & Hjortst.), *Gloeodontia subasperispora* (Litsch.) E. Larss. & K.H. Larss. (as *Gloeocystidiellum subasperisporum* (Litsch.) J. Erikss. & Ryv.), *Hermanssonia centrifuga* (P. Karst.) Zmitr. (as *Phlebia centrifuga* P. Karst.), *Odonticium romellii* (S. Lundell) Parmasto, *Phlebia segregata* (Bourdot & Galzin) Parmasto, *Sistotrema muscicola* (Pers.) S. Lundell, *Suillosporium cystidiatum* (D.P. Rogers) Pouzar and *Tubulicrinis* spp. From the larch-dominated stand with *Picea abies*, *Pinus cembra* and *Sorbus aucuparia* L. admixture, the following species were reported: *Amyloxenasma allantosporum* (Oberw.) Hjortstam & Ryvarden (as *Phlebiella allantospora* (Oberw.) K.H. Larss. & Hjortstam), *Athelopsis lacerata* (Litsch.) J. Erikss. & Ryvarden, *A. subinconspicua* (Litsch.) Jülich, *Basidiodendron caesiocinereum* (Höhn. & Litsch.) Luck-Allen, *Clavulicium delectabile* (H.S. Jacks.) Hjortstam (as *Membranomyces delectabile* (H.S. Jackson) Kotiranta & Saarenoksa), *Kneiffiella floccosa* (Bourdot & Galzin) Jülich & Stalpers (as *Hyphodontia floccosa* (Bourdot & Galzin) J. Erikss.) and *Tubulicrinis medius* (Bourdot & Galzin) Oberw.

Wood-inhabiting funga of the Ukrainian arolla pine communities is very poorly studied. Shevchenko (1972) mentioned *Fomitopsis pinicola* (Sw.) P. Karst., *Gloeophyllum sepiarium* (Wulfen) P. Karst. and *Porodaedalea pini* (Brot.) Murrill (as *Phellinus pini* (Thore) Pil.) as the species occurring on wood of arolla pine and dwarf mountain pine (*Pinus mugo* Turra). In addition, Shevchenko revealed the characteristic root rot caused, in his opinion, by *Phaeolus schweinitzii* (Fr.) Pat. on *P. cembra* in the Osmoloda Forestry (the Gorgany Mountain Range). The fruitbodies of the species, although, were not found (Shevchenko, 1972).

Since the data on tree pathogenic fungi published by Shevchenko in 1972, no more recent records of wood-inhabiting fungi from the Ukrainian arolla pine forests are known. In the recently published monograph on fungal diversity of the protected areas in the Ukrainian Carpathians (Dudka et al., 2019), species composition of such ecosystems is described as rather limited.

Materials and Methods

This article presents the results of five field surveys in the primeval arolla pine forests in the territory

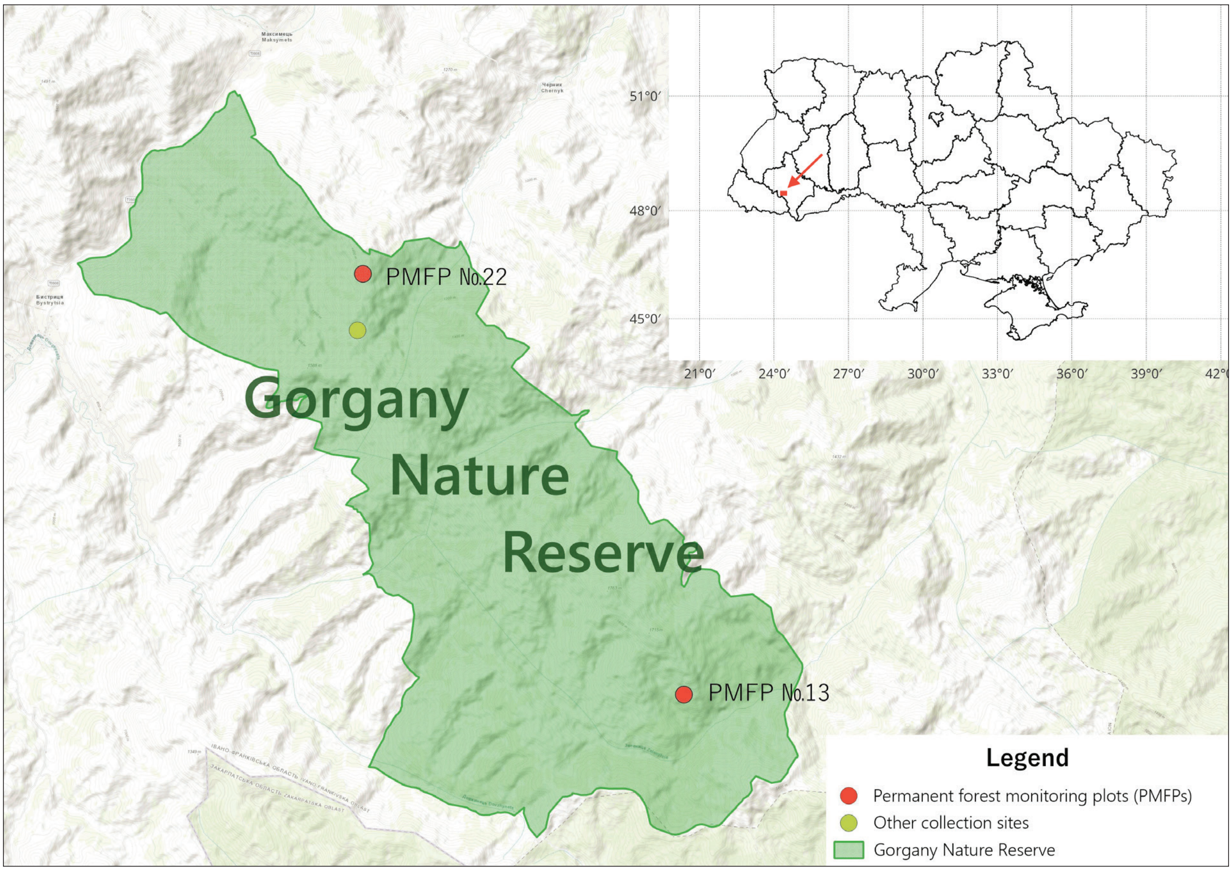

Fig. 1. Location of the studied sites

of Gorgany Nature Reserve (Fig. 1). We randomly examined fallen dead logs, branches and standing dead trunks within the permanent forest monitoring plots (PFMPs) No 22 and No 13, as well as their closest vicinities. We carried out surveys at PFMP No 22 on three separate occasions (21 October 2020, 13 October 2022 and 19 July 2023) and at PFMP No 13 on two occasions (10 August 2022 and 12 July 2023). In addition, we report one record from a spruce log fallen across the forest trail near PFMP No 6 (13 October 2022).

Original descriptions of the study sites were provided by Gorgany Nature Reserve. The studied localities represent the *Pineto (cembrae)-Piceetum (abietis) vaccinioso (myrtilli)-hylocomiosum* association, growing on shallow and rocky brown forest soils. PFMP No 13 (48°24'36"N, 24°23'28"E) occupies an area of 1 ha on the steep (29–32°) southwestern (209°) slopes of Dovbushanka Mt. at altitudes of 1250–1290 m a.s.l. The single-layered stand is dominated by *Picea abies* with the admixture of *Pinus cembra*, *Abies alba* and *Betula pendula*. The underbrush is represented by solitary trees of *Sorbus aucuparia*. PFMP No 22 (48°28'00"N, 24°19'11"E) occupies an area of 0.5 ha on the steep (18–40°) western (250°) slopes of Berezovachka Mt. at altitudes of 1450–1500 m a.s.l. The two-layered stand is composed of *Pinus cembra* representing the upper layer and *Picea abies* together with *Abies alba* and *Sorbus aucuparia* forming the canopy layer. The underbrush is absent. The area of PFMP No 22 belongs to the "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" UNESCO Natural World Heritage Site.

For each specimen, we recorded detailed information on its substrate (tree species, size, wood decay stage and type). Wood decay stages are given according to the classification of Renvall (1995). Specimens are deposited in the Fungarium of the National Herbarium of Ukraine (KW-M) at the M.G. Kholodny Institute of Botany, NAS of Ukraine. In those cases where confident specific identification was possible in the field, we recorded the species occurrence without collecting a sample. Such species are referred to as "not." according to Kotlaba (1999).

Microscopic structures of the fungal fruitbodies were studied in water, 5% KOH solution and Melzer's reagent (Hjortstam et al., 1987).

The species were identified according to Hjortstam et al. (1987), Hansen & Knudsen (1997), Bernicchia & Gorjón (2010), Knudsen & Vesterholt (2012), Ryvarden & Melo (2014) and Læssøe & Petersen (2019). Scientific names of the taxa are provided according to the *Index Fungorum* database (https://www.indexfungorum.org/).

The map of the study sites (Fig. 1) was created using QGIS 3.28.0 software.

Results

We provide below a list of 30 wood-inhabiting *Basidiomycota* recorded in the primeval arolla pine forests of Gorgany Nature Reserve. Among these, we include a previously published (Bohoslavets, Prydiuk, 2023) record of *Hymenochaete fuliginosa* (Fr.) Lév. to gather all finds from the study area in one comprehensive list.

***AGARICOMYCETES* Doweld**

***AGARICALES* Underw.**

***Cystostereaceae* Jülich**

***Cystostereum murrayi* (Berk. & M.A. Curtis) Pouzar**

PFMP No 22, on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Dacrymyces stillatus* and *Hypochnicium cremicolor*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71553).

***Hygrophoraceae* Lotsy**

***Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys**

PFMP No 22, on dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Aphanobasidium subnitens* and *Ceraceomyces eludens*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71554).

***Mycenaceae* Overeem**

***Mycena maculata* P. Karst.**

PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia decipiens* and *A. fibulata*, 13 October 2022, leg. O. Bohoslavets, det. M. Prydiuk (KW-M71527).

***Radulomycetaceae* Leal-Dutra, Dentinger & G.W. Griff.**

***Aphanobasidium subnitens* (Bourdot & Galzin) Jülich**

PFMP No 22, on the side branch of dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Ceraceomyces eludens* and *Lichenomphalia umbellifera*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71555).

***ATHELIALES* Jülich**

***Atheliaceae* Jülich**

***Athelia decipiens* (Höhn. & Litsch.) J. Erikss.**

Vicinity of PFMP No 22, on the fragment of dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 2, with *Fomitopsis pinicola*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71535); PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia fibulata* and *Mycena maculata*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71536).

***A. fibulata* M.P. Christ.**

PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia decipiens* and *Mycena maculata*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71537).

***Piloderma byssinum* (P. Karst.) Jülich**

PFMP No 22, on the bark of dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 3, with *Amylostereum areolatum*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71538).

***AMYLOCORTICIALES* Jülich**

***Amylocorticiaceae* Jülich**

***Ceraceomyces eludens* K.H. Larss.**

PFMP No 22, on dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Aphanobasidium subnitens* and *Lichenomphalia umbellifera*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71556).

***AURICULARIALES* Bromhead**

***Auriculariaceae* Fr.**

***Alloexidiopsis calcea* (Pers.) L.W. Zhou & S.L. Liu**

PFMP No 13, on dead log of *Picea abies* 15 cm in diameter, white rot, decay stage 1, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71557).

***Exidia nigricans* (With.) P. Roberts**

PFMP No 22, on standing dead trunk of *Picea abies* 15 cm in diameter, white rot, decay stage 1, 19 July 2022, not. O. Bohoslavets.

***CANTHARELLALES* Gäum.**

***Botryobasidiaceae* Jülich**

***Botryobasidium isabellinum* (Fr.) D.P. Rogers**

PFMP No 13, on remnants of dead log of *Picea abies* and unrecognizable polypore (*Phellinus viticola*?) attached to it, brown rot, decay stage 5, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71558);

***B. vagum* (Berk. & M.A. Curtis) D.P. Rogers**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Hyphoderma occidentale* and *Tubulicrinis glebulosus*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71539); PFMP No 13, on the remnants of bark on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Dacrymyces stillatus*, *Neoantrodia serialis* and *Trichaptum abietinum*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71559); on dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 2, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71560).

***GLOEOPHYLLALES* Thorn**

***Gloeophyllaceae* Jülich**

***Veluticeps abietina* (Pers.) Hjortstam & Tellería**

PFMP No 13, on dead log of *Picea abies* 9 cm in diameter, white rot, decay stage 1, with *Phellinus viticola*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71561);

***HYMENOCHAETALES* Oberw.**

***Hymenochaetaceae* Donk**

***Hymenochaete fuliginosa* (Fr.) Lév.**

PFMP No 22, on dead log of *Pinus cembra* 30 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71523).

***Phellinus viticola* (Schwein.) Donk**

PFMP No 22, on standing dead trunk of *Picea abies* 8 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71542); on fallen branch of *Picea abies* 3 cm in diameter, white rot, decay stage 1, 19 July 2023, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 26 cm in diameter, white rot, decay stage 2, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71540); on dead log of *Picea abies* 5 cm in diameter, white rot, decay stage 3, with *Xylodon asper*, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71541); on dead log of *Picea abies* 14 cm in diameter, white rot, decay stage 3, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71562); on standing dead trunk of *Picea abies* 14 cm in diameter, white rot, decay stage 2, 12 July 2023, not. O. Bohoslavets; on dead log of *Picea abies* 9 cm in diameter, white rot, decay stage 1, with *Veluticeps abietina*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71563);

***Tubulicrinis glebulosus* (Fr.) Donk**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum* and *Hyphoderma occidentale*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71543).

***Schizoporaceae* Jülich**

***Xylodon asper* (Fr.) Hjortstam & Ryvarden**

PFMP No 13, on dead log of *Picea abies* 5 cm in diameter, white rot, decay stage 3, with *Phellinus viticola*, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71544); PFMP No 22, on dead log of *Picea abies* 7 cm in diameter, white rot, decay stage 3, with *Xenasmatella vaga*, 19 July 2023, leg. & det. O. Bohoslavets (KW-M71564).

Incertae sedis

***Trichaptum abietinum* (Pers. ex J.F. Gmel.) Ryvarden**

PFMP No 13, on the remnants of bark on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum, Dacrymyces stillatus* and *Neoantrodia serialis*, 12 July 2023, not. O. Bohoslavets; PFMP No 22, on dead log of *Picea abies* 13 cm in diameter, brown rot, decay stage 2 with *Fomitopsis pinicola*, 19 July 2023, not. O. Bohoslavets.

***POLYPORALES* Gäum.**

***Fomitopsidaceae* Jülich**

***Fomitopsis pinicola* (Sw.) P. Karst.**

Vicinity of PFMP No 22, on the fragment of dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 2, with *Athelia decipiens*, 21 October 2020, not. O. Bohoslavets; PMFP No 22, on standing dead trunk of *Picea abies* 11 cm in diameter, brown rot, decay stage 2, 19 July 2022, not. O. Bohoslavets; on dead log of *Picea abies* 13 cm in diameter, brown rot, decay stage 2 with *Trichaptum abietinum*, 19 July 2023, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 26 cm in diameter, brown rot, decay stage 3, 12 July 2023, not. O. Bohoslavets.

***Neoantrodia serialis* (Fr.) Audet**

PFMP No 13, on dead log of *Picea abies* 24 cm in diameter, brown rot, decay stage 2, with *Botryobasidium vagum, Dacrymyces stillatus* and *Trichaptum abietinum*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71565).

***Hyphodermataceae* Jülich**

***Hyphoderma occidentale* (D.P. Rogers) Boidin & Gilles**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum* and *Tubulicrinis glebulosus*, 13

October 2022, leg. & det. O. Bohoslavets (KW-M71545).

***Pycnoporellaceae* Audet**

***Pycnoporellus fulgens* (Fr.) Donk**

PFMP No 22, on lying dead trunk of *Picea abies* 5 cm in diameter, brown rot, decay stage 2, 13 October 2022; leg. & det. O. Bohoslavets (KW-M71546).

Incertae sedis

***Climacocystis borealis* (Fr.) Kotl. & Pouzar**

PFMP No 13, on dead log of *Picea abies* 21 cm in diameter, white rot, decay stage 4, 12 July 2023, not. O. Bohoslavets.

***Hypochnicium albostramineum* (Bres.) Hallenb.**

PFMP No 22, on the bark on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 1, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71547).

***H. cremicolor* (Bres.) H. Nilsson & Hallenb.**

PFMP No 22, on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Cystostereum murrayi* and *Dacrymyces stillatus*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71566).

***RUSSULALES* Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David**

***Echinodontiaceae* Donk**

***Amylostereum areolatum* (Chaillet ex Fr.) Boidin**

PFMP No 22, on dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 3, with *Piloderma byssinum*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71548).

***Stereaceae* Pilát**

***Stereum sanguinolentum* (Alb. & Schwein.) Fr.**

PFMP No 22, on the underside of the fallen branch of *Pinus mugo* 12 cm in diameter, white rot, decay stage 1, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71549).

***Xenasmataceae* Oberw.**

***Xenasmatella vaga* (Fr.) Stalpers**

PFMP No 22, on dead log of *Picea abies* 7 cm in diameter, white rot, decay stage 3, with *Xylodon asper*, 19 July 2023, not. O. Bohoslavets.

***TRECHISPORALES* K.H. Larss.**

***Hydnodontaceae* Jülich**

***Brevicellicium olivascens* (Bres.) K.H. Larss. & Hjortstam**

Vicinity of PFMP No 6, UNESCO Natural World Heritage Site, primeval arolla pine forest, 48°27'49"N, 24°19'10"E, 1415 m a.s.l., on dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 3, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71550).

***DACRYMYCETES* Doweld**

***DACRYMYCETALES* Henn.**

***Dacrymycetaceae* J. Schröt.**

***Dacrymyces stillatus* Nees**

PFMP No 22, on fallen branch of *Picea abies* 7 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71551); on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Cystostereum murrayi* and *Hypochnicium cremicolor*, 19 July 2022, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 30 cm in diameter, white rot, decay stage 3, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71552); on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum, Neoantrodia serialis* and *Trichaptum abietinum*, 12 July 2023, not. O. Bohoslavets.

Discussion

The recorded fungi belong to 27 genera, 18 families, 11 orders and 2 classes. Almost all species (except for *Dacrymyces stillatus* classified in *Dacrymycetes*) belong to *Agaricomycetes*, in which *Polyporales* and *Hymenochaetales* are the largest orders represented in our records by seven and five species, respectively. The *Atheliaceae* and *Hymenochaetaceae* are the best represented families, with three species in each.

According to the trophic strategy, most of the species turned out to be saprobic, except for mycorrhizal *Piloderma byssinum* and a basidiolichen *Lichenomphalia umbellifera*. White rotters are the predominant group among wood-decaying fungi — only four of the revealed species (*Fomitopsis pinicola*, *Neoantrodia serialis*, *Pycnoporellus fulgens* and *Veluticeps abietina*) are causing brown rot. Host trees on which the species were recorded are presented in Table 1. *Athelia decipiens* and *Botryobasidium vagum* were the only species recorded on both spruce and arolla pine wood.

Out of 30 species, 17 (*Alloexidiopsis calcea*, *Amylostereum areolatum*, *Aphanobasidium subnitens*, *Athelia decipiens*, *A. fibulata*, *Botryobasidium isabellinum*, *B. vagum*, *Brevicellicium olivascens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *H. cremicolor*, *Phellinus viticola*, *Piloderma byssinum*, *Tubulicrinis glebulosus* and *Xylodon asper*) are reported here for the first time in Gorgany Nature Reserve. For *Tubulicrinis glebulosus* this is the second report from the country, since Shevchenko (2018) recorded the species

Table 1. **Fungi recorded in the primeval forests with arolla pine in Ukraine and associated host tree species**

Species of fungi	*Picea abies*	*Pinus cembra*	*Pinus mugo*
Alloexidiopsis calcea	+		
Amylostereum areolatum	+		
Aphanobasidium subnitens		+	
Athelia decipiens	+	+	
Athelia fibulata		+	
Botryobasidium isabellinum	+		
Botryobasidium vagum	+	+	
Brevicellicium olivascens	+		
Ceraceomyces eludens		+	
Climacocystis boreali	+		
Cystostereum murrayi	+		
Dacrymyces stillatus	+		
Exidia nigricans	+		
Fomitopsis pinicola	+		
Hymenochaete fuliginosa		+	
Hyphoderma occidentale		+	
Hypochnicium albostramineum		+	
Hypochnicium cremicolor	+		
Lichenomphalia umbellifera		+	
Mycena maculata		+	
Neoantrodia serialis	+		
Phellinus viticola	+		
Piloderma byssinum	+		
Pycnoporellus fulgens	+		
Stereum sanguinolentum			+
Trichaptum abietinum	+		
Tubulicrinis glebulosus		+	
Veluticeps abietina	+		
Xenasmatella vaga	+		
Xylodon asper	+		

in Ichnia National Nature Park on wood of *Pinus sylvestris*.

Five species, namely *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* and *H. cremicolor*, are new to Ukraine. The latter species was previously reported from Sviati Hory National Nature Park but, upon closer examination, Akulov & Ordynets (2011) re-identified the specimen as *Hypochnicium wakefieldiae* (Bres.) J. Erikss.

Among the records, *Cystostereum murrayi*, *Phellinus viticola* and *Pycnoporellus fulgens* are commonly considered indicators of the naturalness of forest ecosystems (Kotiranta, Niemelä, 1993; Parmasto, Parmasto, 1997; Tortić, 1998; Holec, 2004, 2008).

Holec (2008) and Kotiranta & Niemelä (1993) listed *Cystostereum murrayi* among the most demanding species in their indicator fungi lists, occurring exclusively in natural forests. Recorded at an elevation of nearly 1470 m a.s.l., this is so far the uppermost known locality of the species in Ukraine.

Phellinus viticola (Fig. 2) is another collected species warranting particular attention. In Ukraine, the species had previously been known only from the territories of the Carpathian National Nature Park and Marmarosy Massif of the Carpathian Biosphere Reserve (Dudka et al., 2019). Pilát was the first to discover the species (as *Phellinus isabellinus* (Fr.) B. & G.) in 1937 in the Berlebash stream valley (Kavina, Pilát, 1942; Holec, 2002). Almost 80 years later, Akulov (2016) published two more locations, in the primeval spruce forest near the Lysycha subalpine meadow and in old-growth spruce forest covering the slopes of Petros Marmaroskyi mountain.

Albeit *P. viticola* is a poorly known species in Ukraine, the striking abundance of its basidiomata observed within the study sites on moderately rotten woody debris with relatively small diameters (down to 3 cm) aligns remarkably well with the ecological characteristics mentioned in the literature. According to Pouska et al. (2013), in an old-growth mountain spruce forest in the Bohemian Forest (Czech Republic) it is, similarly, one of the most abundantly occurring species on naturally fallen spruce logs. The fruitbodies of *P. viticola* are restricted to moderately decomposed wood and may be produced with a relatively small mycelial mass (Renvall, 1995; Rajala et al., 2015). The distribution of this species is also shown to be significantly affected by the connectivity between logs suitable for colonization (Jönsson et al., 2008).

Although *P. viticola* is generally not considered rare (Ryvarden, Melo, 2014; Læssøe, Petersen, 2019), the species distribution is clearly limited by the availability and spatial connectivity of suitable substrata. We believe that this feature, together with the basidiomata abundance and their both noticeable and well-recognizable appearance, makes it an especially convenient indicator species of the conservational value of European boreo-montane spruce forests. However, the presence of *P. viticola* fruitbodies should not be perceived as direct evidence of an absence of human influence on the

Fig. 2. General view of basidiomata of *Phellinus viticola* (KW-M71542)

area, but rather could be seen as a sign of existence of some fundamental traits of a natural ecosystem, making it worthy of protection.

Since the vast majority of the recorded species are represented by a single find, we conclude that the diversity of wood-inhabiting *Basidiomycota* in the Ukrainian primeval arolla pine forests requires further research. However, some general features of the fungal communities of these habitats can already be noted.

The species composition of *Basidiomycota* per individual fallen log is found to be quite poor: we could not find more than four fungal species on any of the examined pieces of wood. The fungi forming thin resupinate corticioid basidiocarps on the underside of the substrate clearly prevail in the species composition. This trend seems to be a consequence of a lack of moisture in the surveyed treeline stands growing on shallow rocky soils, also resulting in the well-documented phenomenon of slow wood decay in subalpine habitats (Shevchenko, 1972; Lambert et al., 1980; Kueppers et al., 2004; Bisht et al., 2014). Further studies of wood-inhabiting fungal communities in the Ukrainian arolla pine forests will provide valuable insights into the wood decay dynamics in these ecosystems, which are constantly exposed to harsh climatic conditions and threatened with substantial area decline due to ongoing climate changes (Kuzemko et al., 2018).

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Ethics Declaration

The authors declare no conflict of interest.

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Деякі базидієві гриби, асоційовані з деревним субстратом, із пралісів з участю *Pinus cembra* в Україні

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Реферат. Угруповання з участю *Pinus cembra* належать до найрідкісніших та найменш вивчених оселищ Європи. У статті наведено 30 видів базидієвих грибів, асоційованих з деревним субстратом, виявлених у кедрових пралісах природного заповідника "Горгани" (Українські Карпати). П'ять видів, а саме *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* та *H. cremicolor*, є новими для території України. З-поміж усіх знахідок, *Cystostereum murrayi*, *Phellinus viticola* та *Pycnoporellus fulgens* заслуговують на особливу увагу, оскільки вони є біоіндикаторами природних лісових екосистем. Видовий склад базидієвих грибів на індивідуальних деревних рештках виявився досить бідним. Серед знахідок переважають гриби, що формують тонкі кортиціоїдні плодові тіла на нижній стороні субстрату, що вказує на нестачу вологи в обстежених деревостанах на верхній межі лісу. Для кожної знахідки наведено детальний опис субстрату та місця збору. Подано огляд попередніх досліджень різноманіття базидієвих грибів, асоційованих з деревним субстратом, у лісах з участю сосни кедрової європейської.

Ключові слова: верхня межа лісу, рідкісні види, Українські Карпати, *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *Hypochnicium cremicolor*, *Phellinus viticola*

VEGETATION SCIENCE, ECOLOGY, CONSERVATION
ГЕОБОТАНІКА, ЕКОЛОГІЯ, ОХОРОНА РОСЛИННОГО СВІТУ

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RESEARCH ARTICLE

Ruderal vegetation of Kyiv City. II. Class *Artemisietea vulgaris*

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Abstract. The article is a continuation of the study on ruderal vegetation of Kyiv City and provides summarized results of syntaxonomic research of the class *Artemisietea vulgaris*. We identified 14 associations and one derivative community belonging to three orders and four alliances. Using ordination and phytoindication analyses, the synmorphology of the communities, their ecological requirements, and habitat preferences were described. It has been shown that the vegetation of *Artemisietea vulgaris* is distributed throughout all districts of the city. According to ecological requirements, we found that main environmental gradients that determine the ordination of different types of stands of *Artemisietea vulgaris* within Kyiv City are thermoregime and light. The diversity of man-made habitats and regional environmental conditions appeared as the most important factors affecting the territorial differentiation of this vegetation type within the city. The contributed data can be used for strategic planning and practical implementation of measures for sustainable urban development and optimization of the urban environment.

Keywords: ordination, phytoindication, syntaxonomy, Ukraine, urboecosystem

Introduction

The article is a continuation of the series of publications on syntaxonomy of the ruderal vegetation of the city of Kyiv, Ukraine. In the previous article, we addressed a detailed description and characterization of the class *Stellarietea mediae* Tx. et al. in Tx. 1950 (Dubyna et al., 2021a). We also provided detailed information about the study area and made a review of the history of investigation of the ruderal vegetation of cities in Ukraine, including the Kyiv urban area. The present article summarizes the results of our syntaxonomic research of the class *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951.

The class *Artemisietea vulgaris* unites thermophilous ruderal plant communities composed of biennial and perennial species (Dengler et al., 2003). They prefer mostly man-made habitats or semi-natural sites within urban areas or human settlements and are associated with well-lit nutrient-rich soils, different regarding their moisture and mechanical structure. The coenoses of the class are widely distributed within Europe, mostly in the temperate and sub-Mediterranean regions (Mucina et al., 2016).

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Vegetation of the class *Artemisietea vulgaris* has some specific features determining the classification process and obtained results. In particular, the heterogeneous composition and floristic structure of plant communities, as well as a wide range of their habitat preferences, make syntaxonomical identification of such phytocoenoses quite a difficult task. It also depends on syntaxonomical concepts of the class used by various scientists. The syntaxonomic structure and circumscription of the class have been repeatedly reviewed by European and Ukrainian phytosociologists (Tüxen, 1950; Rochow, 1951; Oberdorfer, 1957; Braun-Blanquet, 1967; Rivas-Martínez et al., 2001; Borhidi, 2003; Dengler et al., 2003; Bardat et al., 2004; Matuszkiewicz, 2008; Sanda et al., 2008; Solomakha, 2008; Láníková et al., 2009; Tzonev et al., 2009; Biondi et al., 2014; Dubyna et al., 2019, 2022). Thus, some authors included in *Artemisietea vulgaris* only coenoses of hemicryptophytes in anthropogenic and semi-natural habitats, while ruderal plant communities of rhizomatous grasses were considered within a separate class of vegetation, namely *Agropyretea repentis* Oberdorfer, T. Müller et Görs in Oberdorfer et al. 1967 (Moravec et al., 1983; Theurillat et al., 1995). Other researchers, on the contrary, supported another concept of *Artemisietea vulgaris*, including in this class nitrophilous perennial vegetation of the class *Galio-Urticetea* Passarge ex Kopecký 1969 (currently considered as a synonym of the class *Epilobietea angustigolii* Tx. et Preising ex von Rochow 1951) (Dengler, Wollert, 2004; Matuszkiewicz, 2008).

In recent syntaxonomical surveys of European countries, the content and structure of the class *Artemisietea vulgaris* are generally similar. However, the hierarchical rank of nitrophilous biennial plant communities on mesic soils, which considers the alliance *Arction lappae* Tx. 1937, is still controversial. These phytocoenoses occupy a position transitional towards the plant communities of the class *Epilobietea angustifolii* and therefore are considered in both mentioned classes, depending on the syntaxonomical concept adopted by the researchers. The modern syntaxonomic structure of the class *Artemisietea vulgaris* on the pan-European scale was presented by Mucina et al. (2016). The results of syntaxonomic studies of this class in Ukraine were summarized by Dubyna et al. (2019, 2022).

Within the Kyiv urban area, the plant communities of the *Artemisietea vulgaris* were recorded mainly for some parts of the city or for certain habitats. Thus, on the islands of the Dnipro River within Kyiv, Tsukanova (2005) reported three associations of the class: *Balloto nigrae-Leonuretum cardiacae*, *Tanaceto-Artemisietum vulgaris*, and *Artemisietum absinthii*. Chokha (2005) described coenoses of other seven associations and one rankless community on the lawns of the city. Phytosociological aspects of the vegetation of Kyiv railways have been studied by Dziuba et al. (2019, 2022). According to these authors, it is represented by 2 orders, 4 alliances, 11 associations, and 4 derivative communities. Didukh and Alyoshkina (2012), having studied various habitats of the city of Kyiv, mentioned some plant communities with the dominance of diagnostic species of *Artemisietea vulgaris*. It is obvious that phytocoenotic investigations of the class within the Kyiv urban area remain rather fragmentary. Thus establishing the syntaxonomical diversity of *Artemisietea vulgaris* is very important regarding the necessity of further monitoring and management of vegetation in a large urboecosystem of Kyiv City.

The main aims of this study were: (1) to present a classification of vegetation of the class *Artemisietea vulgaris* at the association level within Kyiv City and (2) to evaluate ecological requirements and distribution of the defined associations in the study area.

Materials and methods

Data preparing

Initially, we collected 1164 phytosociological vegetation plot records (relevés) of ruderal vegetation in the territory of Kyiv City in 2016–2020. These relevés were sampled using the Braun-Blanquet approach (Braun-Blanquet, 1964) on plots of 10–25 m^2. We also used geobotanical materials provided by O. Melezhyk (Chokha, 2005). All relevés were stored in the Turboveg for Windows 2.92 database (Hennekens, Schaminée, 2001) and integrated into the database *Anthropogenic vegetation of Ukraine*, registered in the Global Index of Vegetation-Plot Databases (Dengler et al., 2011) with the code EU-UA-11 and included in the European Vegetation Archive (Chytrý et al., 2016). All vegetation layers were combined into one. As bryophytes and lichens were not recorded in the majority of plots and have limited ecological importance in ruderal vegetation, they were excluded from the dataset. We also removed all records of juvenile trees and shrubs as well as records of vascular plant species that were not identified to the species level.

We harmonized nomenclature according to the *Euro+MedBase* (2022).

Data analysis

To build the classification, we used both agglomerative and divisive classification algorithms. In the first step, we made an analysis of all vegetation plots sampled across the Kyiv urban area (1164 relevés) and distinguished the large groups of relevés which are quite different from each other by their species composition. For this purpose, we used a modified TWINSPAN algorithm (Roleček et al., 2009), with three pseudospecies cut levels (0, 5, 25%) and with Sørensen coefficient (Sørensen, 1948) as a measure of cluster heterogeneity. Thereafter we selected those clusters, which corresponded to the class *Artemisietea vulgaris* according to the list of diagnostic species provided by Mucina et al. (2016). After such filtering, our resulting dataset included 270 vegetation plots, which we used for further analysis. We processed selected data using beta-flexible clustering (beta = –0.25, Bray-Curtis dissimilarity, log-transformed percentage abundances) in PC-ORD software (McCune, Mefford, 2011) and distinguished vegetation units corresponding to the associations and their groups (alliances). The optimal number of clusters was selected using the OptimClass test on both stages of the classification procedure (Tichý et al., 2010).

The content of clusters was analyzed by diagnostic (D. sp.), constant (C. sp.), and dominant species in JUICE (Tichý, 2002). The diagnostic value of the species was assessed using the phi coefficient based on the fidelity concept (Chytrý et al., 2002). The threshold values are taken at the level of 0.25. Highly diagnostic species have a phi-coefficient that exceeds 0.5. Species with a non-significant diagnostic value based on Fisher's exact test (P < 0,001) were excluded. Species with a frequency of more than 25% were defined as constant. Highly diagnostic and highly constant species are bolded in the text. Means of phi coefficient for all diagnostic species are presented in Table 1. Syntaxa in the synoptic table are ordered according to the syntaxonomy scheme presented in the Results section.

To identify the vegetation units at different hierarchical ranks, we used the lists of diagnostic species presented in European and Ukrainian phytosociological publications (Chytrý, Tichý, 2003; Jarolímek, Šibík, 2008; Kącki et al., 2013; Mucina et al., 2016; Dubyna et al., 2019). Wherever it was possible, we involved type relevés of syntaxa, basically nomenclatural types of associations described from the territory of Ukraine. To distinguish the rankless (derivative) communities, we used the Kopecký and Hejný approach (Kopecký, Hejný, 1974).

The structure of the class *Artemisietea vulgaris* at the high-rank syntaxonomic level, as well as names of associations, are given according to Dubyna et al. (2019, 2022). Names of orders and alliances follow Mucina et al. (2016). The nomenclature of syntaxa was checked for compliance with the *International Code of Phytosociological Nomenclature* (Theurillat et al., 2021).

Ecological differentiation was conducted using DCA-ordination (Hill, Gauch, 1980) in the R program (William, 2008) operated from JUICE. Indicator values were adopted from Didukh (2011). We also used Didukh's (2011) ecological scales to provide an overview of the ecological requirements of individual associations. We did this analysis in R 4.0.2 (R Core Team, 2022) using the library *ggplot2* (Wickham, 2016) to visualize the results presenting them as box-and-whiskers plots. Boxes reflect the interquartile range (25–75% of observed values), and whiskers 5–95% observed values for each association.

Results

Vegetation classification

A classification dendrogram of the class *Artemisietea vulgaris* within the city of Kyiv is presented in Fig. 1, where four hierarchical groups of clusters are clearly separated. Group 1 (clusters 1–3) represents vegetation plots dominated by tall perennial, nutrient-demanding dicots which are traditionally considered to be the alliance *Arction lappae*. Group 2 (clusters 4–10) we identified as alliance *Dauco-Melilotion* which unites xero-mesophytic vegetation dominated by biennial species on anthropogenic stony and gravelly substrates. Vegetation plots that united thermophilous anthropogenic vegetation on dry soils and were comprised within cluster group 3 (clusters 11–14) we recognized as the *Onopordion acanthii* alliance. The last group 4 (clusters 15–20) includes semi-natural and ruderal vegetation with a high incidence of perennial grasses which we assigned to the alliance *Convolvulo*

Table 1. **Synoptic table with percentage frequency and modified fidelity index phi coefficient**
Shortened synoptic table of the class *Artemisietea vulgaris* in Kyiv. Percentage frequency and modified fidelity index (phi coefficient × 100) superscripted are shown. Only species with frequency more than 25 % and phi coefficient more than 0.25 in at least one column are included and shaded in grey (with phi> 50 in dark grey; with phi< 50 in light grey). Species within clusters are arranged in descending order of fidelity index.

Number of association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Number of plots	**61**	**22**	**5**	**14**	**22**	**5**	**15**	**17**	**3**	**15**	**11**	**17**	**23**	**19**	**21**
Convolvulus arvensis	**$68^{48.1}$**	$17^{4.7}$	.	.	$27^{13.6}$	.	$18^{5.9}$	$14^{2.6}$	.	.	$18^{5.9}$	.	.	5	.
Amaranthus albus	$12^{25.9}$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago lanceolata	$43^{25.6}$	$33^{17.7}$	.	$28^{10.8}$	9	.	$27^{12.7}$	.	.	.	$36^{20.2}$	.	4	.	**62**
Medicago lupulina	4	**$100^{89.9}$**	.	.	.	20	.	.	.	.	.	.	.	.	.
Trifolium repens	.	**$75^{80.6}$**	.	.	.	.	9	.	.	.	.	.	.	.	.
Rumex confertus	.	**$58^{75.3}$**	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium arvense	.	**$58^{75.3}$**	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus corniculatus	.	**$58^{75.3}$**	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa pratensis	$18^{12.3}$	**$75^{74.3}$**	.	.	5	.	.	.	.	.	.	.	.	.	.
Agrostis capillaris	4	**$58^{72.8}$**	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca rubra	4	**$58^{72.8}$**	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense	.	**$67^{64.3}$**	.	.	.	20	.	.	.	.	.	.	.	.	.
Centaurea jacea	.	$33^{56.4}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla reptans	$4^{1.9}$	$33^{53.3}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Glechoma hederacea	$4^{1.9}$	$33^{53.3}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Bromus hordeaceus	.	$25^{48.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis minor	.	$33^{46.3}$	.	.	5	.	.	.	.	.	9	.	.	.	.
Achillea millefolium	7	**$75^{44.3}$**	.	**$64^{44.3}$**	9	.	.	.	$33^{13.4}$	.	.	.	9	$31^{4.3}$	.
Phleum pratense	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium arvense	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium verum	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Malva thuringiaca	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Fragaria vesca	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Argentina anserina	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex acetosella	.	$27^{39.7}$	.	.	.	.	.	.	.	.	.	.	.	.	.

Lolium perenne	7	**58**$^{36.3}$	20	.	9	.	.	.	.	.	$9^{18.7}$	.	32	11	.
Schedonorus pratensis	.	$25^{33.1}$	.	.	.	.	.	.	.	.	9	.	9	$5^{14.5}$	
Arctium tomentosum	.	27^{31}	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica chamaedrys	.	18^{28}	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia austriaca	.	.	**100**$^{\mathbf{100.0}}$	.	.	.	.	.	.	.	.	.	.	.	.
Setaria pumila	4	8	**100**$^{\mathbf{70.8}}$	.	.	.	$18^{4.6}$	.	.	.	.	29^{13}	.	$16^{2.7}$	12
Diplotaxis tenuifolia	4	.	**60**$^{49.5}$	.	.	.	$18^{13.7}$	.	.	.	$27^{13.7}$	.	.	.	.
Bromopsis inermis	.	.	.	**100**$^{\mathbf{91.1}}$	5	.	.	14	.	.	.	.	.	.	.
Salsola tragus	.	.	.	$45^{48.7}$	.	.	.	.	.	.	.	.	.	.	.
Atriplex prostrata	.	.	.	$28^{40.4}$	.	.	.	.	.	.	.	.	4	5	.
Calamagrostis epigejos	11	.	.	$31^{4.3}$	**100**$^{\mathbf{55.6}}$	**60**$^{32.8}$	.	$29^{6.7}$	33^{10}	.	.	.	17	.	.
Anisantha sterilis	.	.	.	.	$28^{29.2}$	.	.	.	.	.	.	.	.	.	.
Aristolochia clematitis	.	.	.	.	.	**100**$^{\mathbf{97.7}}$	.	.	.	.	.	.	4	.	.
Artemisia campestris	.	.	.	.	.	**60**$^{\mathbf{72.5}}$	.	$14^{10.5}$	.	.	.	.	.	.	.
Poa angustifolia	.	.	.	21^{8}	5	**100**$^{\mathbf{64.9}}$	.	$23^{21.5}$	.	$20^{4.2}$	9	.	.	16	.
Verbascum thapsus	.	.	.	.	$14^{5.8}$	40$^{\mathbf{58.6}}$	9	.	.	.	$9^{1.3}$	$14^{6.5}$	4	.	.
Odontites vulgaris	.	.	.	.	.	**80**$^{\mathbf{56.4}}$	.	.	.	.	.	.	.	.	.
Rumex acetosa	.	$17^{18.7}$	.	.	.	**60**$^{42.5}$	.	.	.	.	.	.	4	.	.
Chondrilla juncea	.	.	.	.	.	$20^{39.8}$	9	.	.	.	$18^{19.2}$	.	.	.	.
Berteroa incana	28	.	.	28	14	20	**100**$^{42.2}$	29	33	26	**55**$^{15.4}$	$43^{8.4}$	26	21	12
Poa compressa	.	.	.	.	.	.	$28^{37.4}$	.	.	.	.	.	.	.	.
Silene latifolia	.	.	.	.	.	.	$28^{33.6}$	.	.	.	.	.	.	.	.
Anthemis ruthenica	.	.	.	.	.	.	$28^{29.2}$	.	.	.	.	.	.	.	.
Asclepias syriaca	.	.	.	.	.	$40^{47.2}$	.	**100**$^{\mathbf{75.6}}$	.	.	.	.	.	.	.
Melampyrum arvense	.	.	.	.	.	.	.	29$^{\mathbf{52.1}}$	.	.	.	.	.	.	.
Fallopia convolvulus	$7^{5.8}$	.	.	.	.	.	.	29^{38}	.	.	9	.	4	.	.
Verbascum phlomoides	.	.	.	.	.	.	.	$34^{36.7}$	.	.	.	.	.	.	.
Tragopogon dubius subsp. *major*	.	.	.	.	14	.	17	.	**67**$^{\mathbf{61.6}}$	.	.	.	.	.	.
Equisetum arvense	.	.	.	.	5	.	.	$29^{19.6}$	**67**$^{\mathbf{56.5}}$	.	.	.	.	.	25
Picris hieracioides	.	.	.	.	.	**60**$^{21.7}$	.	.	**67**$^{\mathbf{52}}$	.	.	.	.	5	18

Table 1 (continued)

Number of association	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Number of plots	**61**	**22**	**5**	**14**	**22**	**5**	**15**	**17**	**3**	**15**	**11**	**17**	**23**	**19**	**21**
Plantago arenaria	.	.	.	.	.	.	$9^{10.1}$	.	$33^{49.2}$	.	.	.	.	.	.
Verbascum lychnitis	.	.	.	.	5	.	$9^{7.5}$	.	$33^{41.7}$	.	$9^{7.5}$	.	.	.	.
Melilotus albus	7	.	.	.	5	.	27^{11}	.	.	**$100^{68.1}$**	27^{11}	29^{12}	.	5	.
Linaria genistifolia	.	.	.	.	.	.	.	.	.	$33^{43.5}$	.	.	.	.	.
Achillea setacea	.	.	.	.	.	**$60^{53.7}$**	.	.	.	**60**$^{47.5}$	9	.	.	.	.
Artemisia absinthium	4	.	20	.	9	.	9	14	.	$47^{27.9}$	**$100^{55.2}$**	14	9	16	.
Medicago sativa subsp. *falcata*	.	.	.	.	14	**60**	9	19	.	.	**55**$^{40.7}$	.	.	5	.
Poa bulbosa	.	.	.	.	.	.	.	.	.	.	$36^{29.2}$	.	.	.	.
Hypericum perforatum	.	.	.	.	.	.	.	.	.	.	$36^{29.2}$	.	.	.	.
Consolida regalis	.	.	.	.	.	.	.	.	.	.	$36^{29.2}$	.	.	.	.
Elytrigia intermedia	.	.	.	.	.	.	.	.	.	.	$36^{29.2}$	.	.	.	.
Anthemis arvensis	.	.	.	.	.	.	$18^{11.8}$	.	.	.	.	**$86^{82.9}$**		.	.
Medicago sativa	.	.	.	.	9		.	.	.	20^{10}	$18^{8.3}$	**$86^{70.7}$**	.	5	.
Grindelia squarrosa	15	.	.	.	9	.	.	.	.	**67**$^{22.1}$	9	**$100^{70.5}$**	.	5	.
Anisantha tectorum	7	.	.	.	.	.	$45^{14.8}$	14		**80**$^{36.9}$	**45**$^{14.8}$	**100**$^{49.7}$	17	16	.
Lepidium ruderale	.	.	.	.	.	.	.	.	.	$20^{19.8}$	.	$43^{49.2}$	.	5	.
Echium vulgare	.	.	.	.	18	.	$27^{7.3}$	.	**100^{59}**	$47^{2.1}$	.	**71**$^{38.7}$	13	5	.
Ballota nigra	7	.	.	.	18	.	.	$29^{12.4}$	.	.	18	.	**$100^{69.1}$**	11	12
Conium maculatum	.	.	.	.	.	.	.	.	.	.	.	.	$27^{40.5}$	.	.
Leonurus cardiaca	.	.	.	.	.	.	.	.	.	.	.	.	$34^{32.2}$	.	.
Sisymbrium officinale	.	.	.	.	.	.	.	.	.	.	.	.	$39^{28.6}$	.	.
Galinsoga parviflora	.	.	.	.	.	.	.	.	.	.	.	.	**52**$^{25.2}$	.	.
Alliaria petiolata	.	.	.	.	.	.	.	.	.	.	.	.	$43^{25.2}$	.	.
Chenopodium album	18	.	.	28$^{\mathbf{50.6}}$	$34^{11.4}$	.	18	.	33	.	.	.	$35^{45.0}$	16^{10}	.
Urtica dioica	.	.	.	.	9	.	.	$29^{27.5}$	.	.	.	.	$30^{29.7}$	.	12
Artemisia vulgaris	.	8	.	$21^{18.1}$	18	.	18	**86**$^{41.2}$	.	.	27	.	$39^{21.6}$	**$100^{50.4}$**	.
Artemisia annua	.	.	.	.	.	.	.	.	.	.	.	.	.	$35^{31.5}$	.

Arctium lappa	.	.	.	.	.	.	.	.	.	.	.	.	.	41$^{27.6}$	.
Iva xanthiifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	35$^{25.7}$	.
Arrhenatherum elatius	.	.	.	21	.	.	.	.	.	.	.	.	4	5	**100**
Taraxacum sect. *Taraxacum*	28$^{24.8}$	**100**$^{49.4}$	.	15	5	.	18	14	.	.	18	.	4	16	**88**
Erigeron canadensis	28	.	**60**$^{8.2}$	21	14	.	**64**$^{15.9}$	14	**67**$^{17.6}$	**100**$^{36.2}$	18	**71**$^{20.2}$	17	32	**50**
Elytrigia repens	**93**$^{25.6}$	**100**$^{25.4}$	.	**64**^{12}	**77**$^{13.2}$	**100**$^{25.4}$	**91**$^{20.5}$	**86**$^{17.8}$	.	.	45	.	**61**	47$^{4.5}$	**62**
Oenothera biennis	.	.	.	.	9	40^{31}	.	.	.	.	9	29$^{25.7}$	9	.	.
Potentilla argentea	18	25	40	18	.	.	27	.	.	47	**55**$^{29.2}$	43	4	.	25
Anchusa officinalis	11	.	.	.	5	.	.	.	33^{27}		36$^{30.2}$	.	.	11	12
Ambrosia artemisiifolia	4	.	**60**$^{6.1}$	**78**$^{19.8}$	22	.	**64**$^{13.5}$	.	33	**87**$^{33.5}$	**55**$^{8.6}$	**86**$^{25.6}$	39	47	**75**
Lactuca serriola	14	.	.	.	9	.	45$^{24.5}$	14	.	**60**$^{35.8}$	27	.	17	16	12
Euphorbia cyparissias	11	8	.	.	5	40	9	**57**$^{34.4}$	33	.	9	.	4	.	12
Daucus carota	.	8	.	.	9	.	27$^{13.8}$	.	**67**$^{47.3}$	.	18	.	9	16	12
Plantago major	4	33$^{38.3}$	.	.	14	.		.		.	.	.	13$^{11.7}$	.	.
Portulaca oleracea	18$^{9.7}$	.	.	.	5	.	45$^{36.9}$	.		.	9	43$^{34.4}$	.	.	.
Lamium purpureum	.	.	.	.		.		.	33$^{25.1}$	.	.	.	.	16$^{18.8}$	.
Erigeron annuus	14	8	.	**50**$^{14.4}$	32	**100**$^{44.8}$	**55**$^{17.2}$	.	**67**$^{24.6}$	.	9	14	13	32$^{3.2}$	.
Setaria viridis	7	.	.	**75**$^{61.2}$	5	.	9	.	.	.	9	.	9	11	12
Polygonum aviculare	39	.	40	28	9	.	18	.	.	47	27	.	39	26	**62**
Dactylis glomerata	11	42$^{26.5}$	.	18	5	.	.	43$^{27.5}$	.	.	.	.	4	32	12
Sisymbrium loeselii	11	.	.	28	.	.	9	.	.	.	18	.	9	5	
Achillea collina	18	8	.	36	14	.	18	43	33	.	18	.	13	5	12
Cichorium intybus	11	17	.	36	14	.	9	.	.	.	9	.	4		
Centaurea borysthenica	.	.	.	.	.	40	.	.	.	.	18	.	.	.	.
Solidago canadensis	4	.	.	.	32	.	.	14	33	.	.	.	17	21	25
Carex hirta	11	17	.	14	5	.	.	.	.	.	.	.	.	5	25
Sonchus oleraceus	.	.	.	.	.	.	.	.	.	.	.	.	9	11	38

Number marks the associations: 1 — *Convolvulo arvensis-Agropyretum repentis*; 2 — *Medicagini lupulinae-Agropyretum repentis*; 3 — *Anisantho-Artemisietum austriacae*; 4 — *Convolvulo-Brometum inermis*; 5 — *Calamagrostietum epigei*; 6 — *Aristolochio-Convolvuletum arvensis*; 7 — *Berteroetum incanae*; 8 — *Asclepiadetum syriacae*; 9 — *Echio-Verbascetum*; 10 — *Melilotetum albo-officinalis*; 11 — *Potentillo argenteae-Artemisietum absinthii*; 12 — *Achilleo millefoliae-Grindelietum squarrosae*; 13 — *Leonuro cardiacae-Ballotetum nigrae*; 14 — *Arctio lappae-Artemisietum vulgaris*; 15 — DC *Arrhenatherum elatius*.

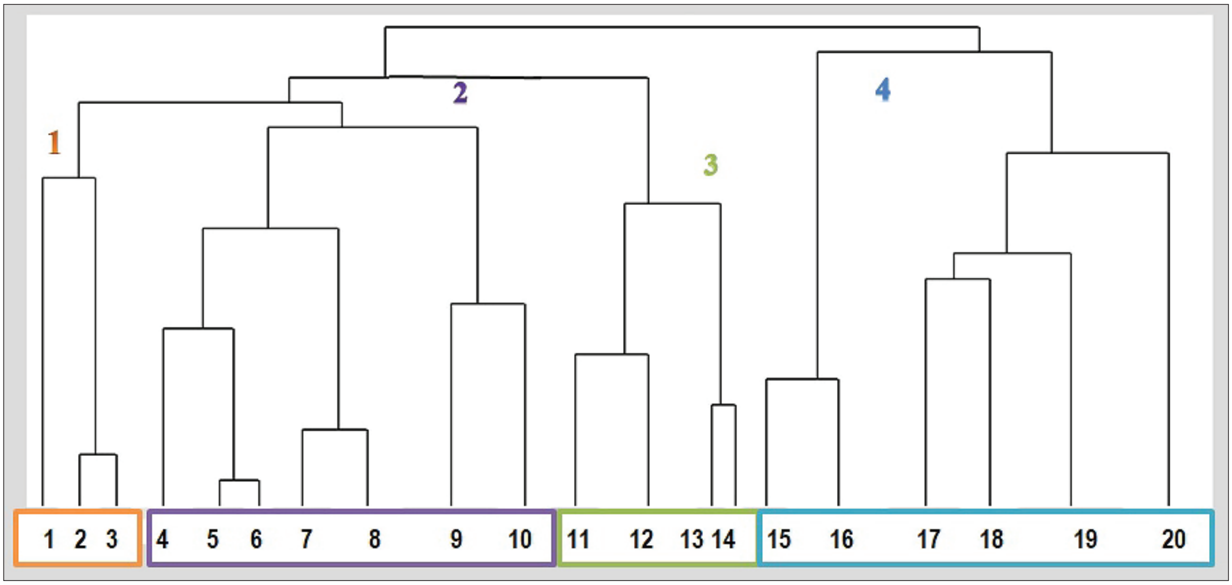

Fig. 1. Dendrogram of the hierarchical classification. Groups: 1 — alliance *Arction lappae*; 2 — alliance *Dauco-Melilotion*; 3 — alliance *Onopordion acanthii*; 4 — alliance *Convolvulo arvensis-Agropyrion repentis*. The numbers of clusters correspond to the vegetation associations detailed below

arvensis-Agropyrion repentis. Within the obtained 20 clusters, we recognized and interpreted 14 vegetation units. In some cases, we considered two clusters as one association. In particular, these were the cases when the dividing of relevés occurred by the dominance of one of diagnostic species.

Description of plant communities

Here we present a brief phytocoenotic characteristics of the associations, taking into account differentiating species and preferred habitats. We do not provide here the definitions of high-rank syntaxa and accept them in accordance with Mucina et al. (2016).

CLUSTER 1. **Ass. *Leonuro cardiacae-Ballotetum nigrae.***

D. sp.: *Alliaria petiolata* (M. Bieb.) Cavara & Grande, ***Ballota nigra*** L. *Chenopodium album* L., *Conium maculatum* L., *Galinsoga parviflora* Cav., *Leonurus cardiaca* L., *Sisymbrium officinale* (L.) Scop., *Urtica dioica* L.

C. sp.: *Ambrosia artemisiifolia* L., *Artemisia vulgaris* L., *Berteroa incana* (L.) DC., *Elytrigia repens* (L.) Nevski, *Lolium perenne* L., *Polygonum aviculare* L.

Phytocoenoses of this association are quite common in all administrative districts of the city and cover various ruderal areas — garbage landfills, lawns, roadsides, strips along walls and fences, areas adjacent to railways, sites near construction grounds, etc. In most cases, habitats are slightly shaded with wet to dry loamy nutrient-rich soils, often with admixtures of building wastes or various organic materials. The stands are usually species-rich (number per relevé varies from 10 to 21, with a total of 79 species), dense (total cover to 90–100%) and two- or three-layered. The dominant species is *Ballota nigra*, while *Elytrigia repens*, *Ambrosia artemisiifolia*, *Conium maculatum*, *Urtica dioica*, *Lolium perenne*, and *Galinsoga parviflora* occur as subdominants in some vegetation plots. An abundant occurrence of other nutrient-demanding species (*Artemisia vulgaris*, *Chelidonium majus* L., *Chenopodium album*, *Oxybasis rubra* (L.) S. Fuentes & al. (*Chenopodium rubrum* L.), *Atriplex prostrata* DC., *Scorzoneroides autumnalis* (L.) Moench (*Leontodon autumnalis* L.), *Alliaria petiolata*, *Arctium tomentosum* Mill., *A. lappa* L., *Taraxacum* F.H. Wigg sect. *Taraxacum*) is also characteristic of this community. Species of dry grasslands (*Achillea collina* (Wirtg.) Heimerl, *A. millefolium* L., *Viola hirta* L., *Oenothera biennis* L., *Artemisia campestris* L., *Euphorbia cyparissias* L., *Bromus squarrosus* L., *Secale sylvestre* Host) are more frequent in stands of phytocoenoses on dry open habitats.

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CLUSTERS 2–3. **Ass. *Arctio lappae-Artemisietum vulgaris.***

D. sp.: *Arctium lappa*, *Artemisia annua* L., ***Artemisia vulgaris***, *Iva xanthiifolia* Nutt.

C. sp.: *Achillea millefolium*, *Ambrosia artemisiifolia*, *Dactylis glomerata* L., ***Elytrigia repens***, *Erigeron annuus* (L.) Desf., *Erigeron canadensis* L., *Polygonum aviculare.*

This community is one of the most common within the territory of Kyiv. It inhabits quite diverse habitats: landfills, edges of fences, roadsides and sidewalks, lawns, abandoned sport grounds, areas near buildings, and industrial sites of the city. We also found these phytocoenoses along railways on the north and west-facing moderate slopes (mean 30–35º). The soils are nutrient-rich clay and chornozems with admixtures of gravel or stones. As a rule, stands are two-layered and reach 120–180 (200) cm in height with total coverage of 80–100%. The upper layer is characterized by the dominance of diagnostic species: tall perennial herbaceous plants of *Artemisia vulgaris* and *Arctium lappa*, sometimes together with *A. tomentosum*. Representatives of *Artemisietea vulgaris* (*Tanacetum vulgare* L., *Daucus carota* L., *Ambrosia artemisiifolia*, *Berteroa incana*, *Artemisia absinthium* L., *Echium vulgare* L., *Melilotus albus* Medik., *Ballota nigra*) and *Stellarietea mediae* (*Erigeron canadensis*, *Iva xanthiifolia*, *Setaria pumila* (Poir.) Roem. & Schult., *Chenopodium album*) included in the middle layer are accompanied by nitrophilous herbs which are characteristic of *Epilobietea angustifolii* class (*Lamium purpureum* L., *Solidago canadensis* L., *Urtica dioica*, *Anthriscus sylvestris* (L.) Hoffm., *Helianthus tuberosus* L.). Within the dense stands, the bottom layer usually is not developed due to shadow of burdock's broad leaves. In semi-closed stands, the lowest layer consists of climbing plants (*Convolvulus arvensis* L.) and some low-growing herbs (*Polygonum aviculare*, *Taraxacum* sect. *Taraxacum*, *Plantago major* L.). In total, the floristic structure of the association is formed by 66 species (from 5 to 15 in some plots).

CLUSTER 4. **DC *Arrhenatherum elatius.***

Dominant species: *Arrhenatherum elatius*

C. sp.: ***Ambrosia artemisiifolia***, ***Arrhenatherum elatius*** (L.) J. Presl & C. Presl, *Carex hirta* L., ***Elytrigia repens***, *Erigeron canadensis*, *Equisetum arvense* L., ***Plantago lanceolata*** L., ***Polygonum aviculare***, *Potentilla argentea* L., *Solidago canadensis*, *Sonchus oleraceus* L., *Taraxacum* sect. *Taraxacum.*

We observed these stands near the railway stations Karavayevi Dachi and Kyiv Volynskyi on flat areas with humid chornozems mixed with gravel. False oat-grass (*Arrhenatherum elatius*) is a native species in the western part of Ukraine where it forms mesic meadows of the class *Molinio-Arrhenatheretea* (Protopopova et al., 2014). Within the territory of Kyiv, *Arrhenatherum elatius* appears like an alien species and spreads actively in the eastern direction. This process is especially successful due to the permanent mowing of the sites on railway slopes and embankments. It makes the dissemination of *Arrhenatherum elatius* very efficient and causes forming of dense stands with a high dominance ability of the mentioned grass. Stands of the community are usually dense with total coverage of 70–80% reaching in height of 100–120 cm. Among the companions, species characteristic of *Artemisietea vulgaris* (*Ballota nigra*, *Elytrigia repens*, *Daucus carota*) and *Molinio-Arrhenatheretea* (*Equisetum arvense*, *Agrostis stolonifera* L., *Carex hirta*, *Vicia cracca* L., *Trifolium hybridum* L.) are noticed.

CLUSTERS 5–6. **Ass. *Melilotetum albo-officinalis.***

D. sp.: *Achillea setacea* Waldst. & Kit., *Ambrosia artemisiifolia*, *Anisantha tectorum* (L.) Nevski (*Bromus tectorum* L.), *Artemisia absinthium*, *Erigeron canadensis*, *Lactuca serriola* L., *Linaria genistifolia* (L.) Mill., ***Melilotus albus***

C. sp.: *Berteroa incana*, *Echium vulgare*, ***Grindelia squarrosa*** (Pursh) Dunal, *Polygonum aviculare*, *Potentilla argentea*

This community is locally distributed within Kyiv City, mainly in Darnytskyi and Dniprovskyi districts. It inhabits anthropogenic areas (around industrial sites, along roads and railways) on shallow well-drained sandy soils with high gravel and stone content. In total, the floristic structure of the association is formed by 23 species (from 8 to 10 in some plots). The two-layered stands reach 80–110 cm in height and have a total cover of 40–50%. The herb layer is usually dominated by *Melilotus albus*. The most characteristic components of the phytocoenoses are xerophilous light-demanding species, such as *Ambrosia artemisiifolia*, *Anisantha tectorum*, *Bromus squarrosus*, *Achillea setacea*, *Capsella bursa-pastoris* (L.) Medik., *Linaria genistifolia*, *Lepidium ruderale* L., *Erigeron canadensis*. Common species of the class *Artemisietea vulgaris* (e.g., *Grindelia squarrosa*, *Echium vulgare*, *Artemisia absinthium*, *Berteroa incana*) are also well-represented.

CLUSTERS 7–8. **Ass. *Berteroetum incanae.***

D. sp.: *Anthemis ruthenica* M. Bieb., *Berteroa incana*, *Poa compressa* L., *Portulaca oleracea* L., *Silene latifolia* Poir.

C. sp.: ***Ambrosia artemiisifolia***, *Anisantha tectorum*, *Daucus carota*, ***Elytrigia repens***, *Echium vulgare*, ***Erigeron annuus***, ***Erigeron canadensis***, *Lactuca serriola*, *Melilotus albus*, *Plantago lanceolata*, *Potentilla argentea.*

This community, dominated by the biennial herb *Berteroa incana*, colonizes well-drained, warm sandy to loamy soils with a high proportion of gravel or stones. We found phytocoenoses along railway tracks, highways, roads, and sidewalks. Chokha (2005) also mentioned them as occurring on abandoned lawns. The association was represented by 15 relevés sampled in all districts of the city. In total, the coenoflora of this association is composed of 48 taxa. A number of species in the vegetation plots is between 6 and 12. The stands are low, two-layered, reaching on average 40–60 cm. The bottom layer is formed by diagnostically important *Berteroa incana*, *Portulaca oleracea*, and species of higher syntaxa, both anthropogenic and natural vegetation, e.g. *Stellarietea mediae* (*Ambrosia artemisiifolia*, *Erigeron canadensis*, *Anisantha tectorum*, *Setaria viridis* (L.) P. Beauv., *Sisymbrium loeselii* L.), *Artemisietea vulgaris* (*Echium vulgare*, *Artemisia vulgaris*, *A. absinthium*, *Daucus carota*, *Melilotus albus*), *Koelerio-Corynephoretea canescentis* (*Plantago arenaria* Waldst. & Kit., *Oenothera biennis*, *Artemisia campestris*). In the lower layer, *Poa compressa*, *Polygonum aviculare*, *Convolvulus arvensis*, and *Medicago lupulina* L. are concentrated. Some grasses (*Elytrigia repens*, *Arrhenatherum elatius*), which overtop the stands, locally form another, third rather loose layer.

CLUSTER 9. **Ass. *Asclepiadetum syriacae.***

D. sp.: *Artemisia vulgaris*, ***Asclepias syriaca*** L., *Dactylis glomerata*, *Euphorbia cyparissias*, *Fallopia convolvulus* (L.) Á. Löve, ***Melampyrum arvense*** L., *Urtica dioica*, *Verbascum phlomoides* L.

C. sp.: *Achillea collina*, *Ballota nigra*, *Berteroa incana*, *Calamagrostis epigejos* (L.) Roth, ***Elytrigia repens***, *Equisetum arvense*

This vegetation type is dominated by the tall herb *Asclepias syriaca*, an invasive plant species of North American origin. Within the Kyiv urban area, this species-poor community occurs on railway slopes (usually of the southern exposure) and roadsides. Soils are often dry, ranging from chornozem to stony. The floristic structure comprised 33 plant species (6–13 per relevé). Stands are usually one- or two-layered, reaching on average 80–100 cm and having a total cover of 60 to 90%. The upper layer consists of the dominant *Asclepias syriaca*, broad-leaved ruderal herbs (*Artemisia vulgaris*, *Urtica dioica*, *Ballota nigra*, *Berteroa incana*, *Chelidonium majus*), and grasses (*Calamagrostis epigejos*, *Elytrigia repens*, *Bromopsis inermis*, *Anisantha tectorum*, *Dactylis glomerata*). In the bottom layer, the most common species are *Equisetum arvense*, *Achillea collina*, *Melampyrum arvense*, *Taraxacum* sect. *Taraxacum*, as well as climbing plants (*Fallopia convolvulus*, *Convolvulus arvensis*).

CLUSTER 10. **Ass. *Echio-Verbascetum.***

D. sp.: *Daucus carota*, ***Echium vulgare***, ***Equisetum arvense***, *Lamium purpureum*, ***Picris hieracioides*** L., *Plantago arenaria*, ***Tragopogon dubius* subsp. *major*** (Jacq.) Vollm., *Verbascum lychnitis* L.

C. sp.: *Achillea millefolium*, *Ambrosia artemisiifolia*, *Anchusa officinalis* L., *Berteroa incana*,*Calamagrostis epigejos*, *Chenopodium album*, ***Erigeron annuus***, ***Erigeron canadensis***, *Euphorbia cyparissias*, *Solidago canadensis.*

This community has a local distribution within Kyiv and was documented by five relevés sampled in Svyatoshynskyi and Holosiyivskyi districts on railway slopes and abandoned building sites. All habitats are associated with open sunny places on sandy soils, sometimes with an admixture of gravel and stones. Stands are not dense (to 60–70% total cover) and are only slightly stratified. The total number of species in the phytocoenoses reaches 40, in some relevés — 10–13. The aspect of communities is determined by a diagnostic species, *Echium vulgare*, with quite conspicuous blue flowers. Ruderal species (e.g., *Humulus lupulus* L., *Picris hieracioides*, *Daucus carota*, *Erigeron canadensis*, *Ambrosia artemisiifolia*, *Erigeron annuus*, *Berteroa incana*), as well as representatives of the psammophytic floristic coenocomplex (*Artemisia campestris*, *Oenothera biennis*, *Plantago arenaria*), are frequent in the species composition.

CLUSTERS 11–12. **Ass. *Achilleo millefoliae-Grindelietum squarrosae.***

D. sp.: *Ambrosia artemisiifolia*, ***Anthemis arvensis*** L., *Anisantha tectorum*, *Echium vulgare*, ***Grindelia squarrosa***, *Lepidium ruderale*, ***Medicago sativa*** L., *Oenothera biennis*, *Portulaca oleracea*

C. sp.: *Berteroa incana*, ***Erigeron canadensis***, *Melilotus albus*, *Potentilla argentea*, *Setaria pumila*

This community was found on railway slopes and waste places on sandy soils with high content of gravel or pebbles. It occurs mainly in Holosiyivskyi, Svyatoshynskyi, and Darnytskyi districts. Stands are normally 50–60 cm tall with a total cover of 60–70%, of which *Grindelia squarrosa* makes up 40–50%. Differentiation into layers is indistinct, but some plants, such as *Echium vulgare*, *Melilotus albus*, *Artemisia absinthium*, sometimes overtop the herb layer. Drought-tolerant heliophilous species (*Anisantha tectorum*, *Ambrosia artemisiifolia*, *Berteroa incana*, *Anthemis arvensis*, *Erigeron canadensis*, *Potentilla argentea*) usually prevail together with herbs characteristic of *Koelerio-Corynephoretea canescentis* class (*Festuca beckeri* (Hack.) Trautv., *Oenothera biennis*, *Artemisia campestris*). The number of species varies from 8 to 12 (the total count is 20).

CLUSTERS 13–14. **Ass. *Potentillo argenteae-Artemisietum absinthii.***

D. sp.: *Anchusa officinalis*, ***Artemisia absinthium***, *Consolida regalis* Gray, *Elytrigia intermedia* (Host) Nevski, *Hypericum perforatum* L., *Medicago sativa* subsp. *falcata* (L.) Arcang., *Melilotus albus*, *Poa bulbosa* L., *Potentilla argentea.*

C. sp.: ***Ambrosia artemisiifolia***, *Anisantha tectorum*, *Artemisia vulgaris*, ***Berteroa incana***, *Diplotaxis tenuifolia* (L.) DC., *Elytrigia repens*, *Lactuca serriola*, *Plantago lanceolata*, *Polygonum aviculare*

This association includes species-rich thermophilous vegetation growing on sunny and dry ruderal sites. In most cases, soils are loamy, mostly with an admixture of gravel and stones, rich in nutrient compounds. We documented this plant community in all districts of the city on building rubble, railway slopes (usually moderate, sun-exposed with south and southwest orientations), along roads, and sidewalks. Stands are not dense (total cover of 40–70%) and quite variable in both their abundance and number of species, but species-rich stands prevail. The number of species per relevé can vary from 9 to 19. In total, 68 taxa were recorded for this association in the study area. Stands reach up to 70–80 cm and are three-layered, of which the upper layer consists of the dominant *Artemisia absinthium* (with a cover of 40–60%) together with other tall ruderal herbs (*Elytrigia repens*, *Artemisia vulgaris*, *Portulaca oleracea*, *Lactuca serriola*, *Daucus carota*). The middle layer frequently consists of herbs characteristic of the class *Artemisietea vulgaris* (*Potentilla argentea*, *Berteroa incana*, *Melilotus albus*, *Grindelia squarrosa*), together with representatives of *Stellarietea mediae* (*Anisantha tectorum*, *Diplotaxis tenuifolia*, *Ambrosia artemisiifolia*, *Eragrostis minor* Host, *Setaria viridis*, *Erigeron canadensis*, *Sisymbrium loeselii*). The most frequent dominants of the bottom layer are climbing plants *Convolvulus arvensis* and *Fallopia convolvulus*. In habitats affected by trampling, the floristic composition of phytocoenoses is characterized by constant participation of *Polygonum aviculare*, *Cichorium intybus* L., *Plantago major*, and *Taraxacum* sect. *Taraxacum*. The occurrence of some species diagnostic for *Koelerio-Corynephoretea canescentis* class (e.g. *Centaurea borysthenica* Gruner, *Artemisia campestris*, *Poa bulbosa*, *Secale sylvestre*, *Scabiosa ochroleuca* L., *Medicago sativa* subsp. *falcata*) is also remarkable.

CLUSTER 15. **Ass. *Convolvulo arvensis-Elytrigietum repentis*** (incl. *Agropyretum repentis*).

D. sp.: *Amaranthus albus* L., *Convolvulus arvensis*, *Elytrigia repens*, *Plantago lanceolata*.

C. sp.: *Berteroa incana*, *Erigeron canadensis*, *Polygonum aviculare*, *Taraxacum* sect. *Taraxacum.*

This association is the most widespread in the territory of Kyiv. It is found along roads, fences, transport routes, park alleys, near buildings, garbage dumps and landfills, and other anthropogenic areas. It is represented by 58 relevés that were sampled from all districts of the city. In most cases, soils are loamy to clayey, often with high calcium content. It also could be found on different anthropogenic substrates with admixtures of sand or stones. The habitats are dry, warm, and well-lit.

The association includes phytocoenoses with the dominance of *Elytrigia repens*, which forms dense, sometimes monodominant stands. *Convolvulus arvensis* is a constant species, with different cover values in various vegetation plots. The association is made of 157 species in total, and their number per relevé varies from 5 to 19. The floristic composition of plant communities is formed by typical ruderal plants (*Berteroa incana*, *Artemisia vulgaris*, *Erigeron canadensis*, *Chenopodium album*, *Lactuca serriola*, *Daucus carota*, *Portulaca oleracea*, *Ambrosia artemisiifolia*, *Erigeron annuus*, *Ballota nigra*) and meadow grasses (*Lolium perenne*, *Poa pratensis* L., *Taraxacum* sect. *Taraxacum*, *Trifolium pratense* L., *Dactylis glomerata*, *Carex hirta*, *Schedonorus pratensis* (Huds.) P. Beauv.). Stands are two- or three-layered, reaching 80–120 cm in height, with dense coverage to 90–100%. The upper layer is characterized by the diagnostic species *Elytrigia repens* usually accompanied by *Chenopodium album*, *Erigeron canadensis*, *Dactylis glomerata*, *Artemisia absinthium*, and *Portulaca oleracea*. The middle layer is made up of *Setaria viridis*, *Digitaria sanguinalis* (L.) Scop., *Potentilla argentea*, *Grindelia squarrosa*, *Berteroa incana*, *Glechoma hederacea* L., *Taraxacum* sect. *Taraxacum*, *Tripleurospermum inodorum* (L.) Sch. Bip., and *Capsella bursa-pastoris*. In the lower layer, mainly *Polygonum aviculare*, *Plantago lanceolata*, and *P. major* frequently occur.

There are two variants distinguished within the association, which differ by their species composition and habitat affiliation. Phytocoenoses of *Convolvulo arvensis-Elytrigietum repentis* var. *Berteroa incana* grows along roads and railways on dry soils with an admixture of sand or stones. This variant is characterized by the predominance of thermophilous plant species which represent classes *Festuco-Brometea* (*Achillea collina*, *Euphorbia cyparissias*, *Festuca valesiaca* Gaudin, *Medicago sativa* subsp. *falcata*, *Viola hirta*) and *Koelerio-Corynephoretea canescentis* (*Centaurea borysthenica*, *Oenothera biennis*, *Chondrilla juncea* L., *Secale sylvestre*).

Plant communities of *Convolvulo arvensis-Elytrigietum repentis* var. *Polygonum aviculare* are typical for lawns, park alleys, and various trampled areas. Well-developed stands consist of representatives of the classes *Stellarietea mediae* (*Lactuca serriola*, *Erigeron canadensis*, *Digitaria sanguinalis*, *Eragrostis minor*, *Galinsoga parviflora*, *Amaranthus albus*) and *Polygono-Poetea annuae* (*Polygonum aviculare*, *Taraxacum* sect. *Taraxacum*, *Plantago lanceolata*, *Lolium perenne*).

CLUSTER 16. **Ass. *Medicagini lupulinae-Agropyretum repentis.***

<u>D. sp.</u>: *Achillea millefolium*, ***Agrostis capillaris*** L., *Arctium tomentosum*, *Argentina anserina* (L.) Rydb., *Bromus hordeaceus* L., ***Centaurea jacea*** L., ***Cerastium arvense*** L., *Cirsium arvense* (L.) Scop., *Dactylis glomerata*, *Elytrigia repens*, *Eragrostis minor*, ***Festuca rubra*** L., *Fragaria vesca* L., *Galium verum* L., ***Glechoma hederacea***, *Lolium perenne*, ***Lotus corniculatus*** L., *Malva thuringiaca* (L.) Vis., ***Medicago lupulina***, *Phleum pratense* L., *Plantago major*, ***Poa pratensis***, ***Potentilla reptans*** L., *Rumex acetosella* L., ***R. confertus*** Willd., *Schedonorus pratensis*, *Taraxacum* sect. *Taraxacum*, ***Trifolium pratense***, ***T. repens*** L., *Veronica chamaedrys* L.

<u>C. sp.</u>: *Plantago lanceolata*, *Potentilla argentea.*

This vegetation type was recorded on the lawns of the city. It is represented by 12 relevés sampled in Shevchenkivskyi, Holosiyivskyi, Pecherskyi, and Solomyanskyi districts. Coenoses are confined to the open well-lit habitats with chornozem or sandy chornozem soils. Plant communities are characterized by high species richness (16–22 species in the relevé with a total taxa number of 54), high density (total cover 80–100%), and height of 80–100 cm of stands. The vertical structure is two-layered. The taller plants are concentrated in the upper layer; of them the most important is a diagnostic species *Elytrigia repens* and several other dominant species (*Schedonorus pratensis*, *Festuca rubra*, *Poa pratensis*, *Dactylis glomerata*). Included in the middle layer usually are *Medicago lupulina*, *Taraxacum* sect. *Taraxacum*, *Trifolium pratense*, *Achillea millefolium*, *Potentilla reptans*, *Plantago lanceolata*. A high frequency of diagnostic species for *Molinio-Arrhenatheretea* class is a characteristic feature of this association.

CLUSTER 17. **Ass. *Convolvulo-Brometum inermis.***

<u>D. sp.</u>: *Achillea millefolium*, *Atriplex prostrata* DC., ***Bromopsis inermis*** (Leyss.) Holub (*Bromus inermis* Leyss.), ***Chenopodium album***, *Salsola tragus* L., ***Setaria viridis***

<u>C. sp.</u>: ***Ambrosia artemisiifolia***, *Berteroa incana*, *Calamagrostis epigejos*, *Cichorium intybus*, ***Elytrigia repens***, ***Erigeron annuus***, *Plantago lanceolata*, *Polygonum aviculare*, *Sisymbrium loeselii.*

Association includes stands of *Bromopsis inermis* that inhabit areas along roads and railways on dry loamy soils with an admixture of sand. It is distributed sporadically in Svyatoshynskyi and Darnytskyi districts. The number of species per plot varies between 8 and 14 species (in total 26 species have been recorded). The herb coverage is usually dense, with total coverage of 90 to 100%. Well-developed two-layer stands reach up to 70–90 cm. They consist of the dominant *Bromopsis inermis*, other grasses (e.g., *Dactylis glomerata*, *Elytrigia repens*, *Setaria viridis*, *Calamagrostis epigejos*, *Poa angustifolia* L., *Arrhenatherum elatius*), and perennial ruderal species (*Artemisia vulgaris*, *Potentilla argentea*). The occurrence of annual plants (*Chenopodium album*, *Ambrosia artemisiifolia*, *Erigeron canadensis*, *Sisymbrium loeselii*, *Atriplex prostrata*, etc.) is also remarkable.

CLUSTER 18. **Ass. *Aristolochio-Convolvuletum arvensis.***

<u>D. sp.</u>: ***Achillea setacea***, ***Aristolochia clematitis*** L., ***Artemisia campestris*** L., *Asclepias syriaca*, *Calamagrostis epigejos*, *Chondrilla juncea*, *Elytrigia repens*, *Erigeron annuus*, ***Odontites***

vulgaris Moench, *Oenothera biennis*, ***Poa angustifolia***, *Rumex acetosa* L., ***Verbascum thapsus*** L.

<u>C. sp.:</u> *Centaurea borysthenica*, *Euphorbia cyparissias*, ***Medicago sativa* subsp. *falcata***, ***Picris hieracioides.***

The communities of the association are sporadically distributed in the study area. We found stands mainly in Desnianskyi District on lower sections of railway slopes with sandy chornozem soils. Phytocoenoses had low species richness (the species number varied from 9 to 13 per relevé). Stands are normally 60–80 (100) cm tall, with a total cover of 60 to 80%. They are usually differentiated into two layers. The upper layer consists of the diagnostic species *Elytrigia repens*, *Poa angustifolia*, *Calamagrostis epigejos*, *Verbascum thapsus*, *Asclepias syriaca*. The bottom layer is made up of several diagnostic species (*Achillea setacea*, *Aristolochia clematitis*, *Erigeron annuus*, *Trifolium arvense* L.) along with *Medicago sativa* subsp. *falcata*, *Rumex acetosa*, *Chondrilla juncea*, *Centaurea borysthenica*, *Picris hieracioides*, etc.

CLUSTER 19. **Ass. *Anisantho-Artemisietum austriacae.***

<u>D. sp.</u>: ***Artemisia austriaca* Jacq.**, *Diplotaxis tenuifolia*, ***Setaria pumila***

<u>C. sp.</u>: ***Ambrosia artemisiifolia***, ***Erigeron canadensis***, *Polygonum aviculare*, *Potentilla argentea*

It is a rare association within the city of Kyiv. Phytocoenoses were recorded only in one locality, between the railway stations Livoberezhna and Darnytsia. It occurs in sunny open dry habitats, e.g. railway slopes with a steepness of 35º. The soils are sandy with a small admixture of pebbles. These plant communities are dominated by *Artemisia austriaca.* Among other species, there are typical xerophytes, such as *Bromus squarrosus*, *Achillea millefolium*, *Grindelia squarrosa*. In total, 13 species were found in the phytocoenoses, on average 7–13 per relevé. The total cover of communities is 40–60%. Stands 50–60 cm tall are one or two-layered. The upper layer (40–60 cm) consists of diagnostically important *Artemisia austriaca*, *Setaria pumila*, together with tall plants of *Ambrosia artemisiifolia*, *Artemisia absinthium*, and *Erigeron canadensis*. The bottom layer (5–15 cm) is made up of *Polygonum aviculare*, *Potentilla argentea*, *Diplotaxis tenuifolia*.

CLUSTER 20. **Ass. *Calamagrostietum epigei.***

<u>D. sp.</u>: *Anisantha sterilis* (L.) Nevski, ***Calamagrostis epigejos***

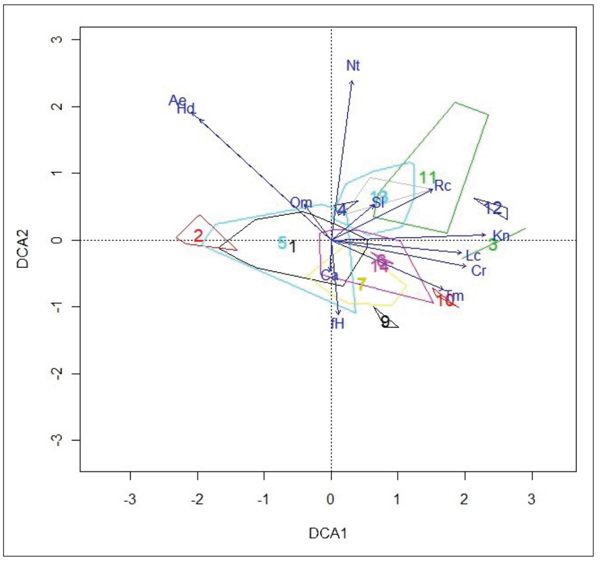

Fig. 2. Results of DCA-ordination of plant communities of the class *Artemisietea vulgaris* by ecological factors: Hd — soil humidity, fH — fluctuating of water level, Rc — soil acidity, Sl — salt regime, Ca — carbonate content, Nt — nitrogen content, Ae — soil aeration, Tm — termoregime, Om — ombroregime, Kn — continentality of climate, Cr — cryoregime, Lc — light regime. The numbers indicate syntaxa that correspond to those given in the classification scheme

<u>C. sp.:</u> *Chenopodium album*, *Convolvulus arvensis*, ***Elytrigia repens***, *Erigeron annuus*, *Solidago canadensis*

The plant communities of the association are widely distributed within the Kyiv urban area. In most cases, habitats are roadsides, lawns, and abandoned sites near buildings. Stands are usually dense, with a total cover of up to 80–100% and a height of 120–150 cm. A total of 94 species were recorded in the plant communities (5–16 per relevé). The vertical structure of phytocoenoses is normally two-layered. In the upper layer, *Elytrigia repens* and *Poa pratensis* were recorded together with the diagnostic *Calamagrostis epigejos*. In the lower layer, *Vicia cracca*, *Polygonum aviculare*, *Plantago lanceolata*, and *Convolvulus arvensis* are frequently concentrated.

Depending on habitat conditions and floristic composition, the following two variants may be distinguished: (a) containing meadow plant species – the variant with *Dactylis glomerata*; (b) consisting of typical ruderal plants — the variant with *Elytrigia repens.* Phytocoenoses of *Calamagrostietum epigei* var. *Dactylis glomerata* occur along fences, as well as in lawns, park sites, and different abandoned areas. This vegetation develops on slightly shaded habitats with mesic to dry soils rich in nutrients. The species diagnostic for *Molinio-Arrhenatheretea* class (e.g., *Poa pratensis*, *Dactylis glomerata*, *Trifolium pratense*, *T. repens*, *Taraxacum* sect. *Taraxacum*, *Lotus corniculatus*, *Equisetum arvense*) are typical for the species composition of these plant communities. On the contrary, the phytocoenoses of *Calamagrostietum epigei* var. *Elytrigia repens* prefer open well-lit habitats with sandy soils. Plant communities were found on roadsides, railway slopes, and the surroundings of parking slots. Stands are characterized by the dominance of typical ruderal plants, such as *Daucus carota*, *Solidago canadensis*, *Erigeron annuus*, *Ambrosia artemisiifolia*, *Artemisia vulgaris*, *Ballota nigra*, *Echium vulgare*, *Erigeron canadensis*, *Melilotus albus*, and *Chenopodium album*. The participation of representatives of the class *Koelerio-Corynephoretea canescentis* (e.g., *Artemisia campestris*, *Oenothera biennis*, *Medicago sativa* subsp. *falcata*) is also notable.

Thus, the classification scheme of the class *Artemisietea vulgaris* within the city of Kyiv in accordance with our results is as follows:

***Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951**

Agropyretalia intermedio-repentis T. Müller et Görs 1969

  Convolvulo arvensis-Agropyrion repentis Görs 1967

    1. *Convolvulo arvensis-Agropyretum repentis* Felföldy 1943

      var. *Berteroa incana*

      var. *Polygonum aviculare*

    2. *Medicagini lupulinae-Agropyretum repentis* Popescu et al. 1980

    3. *Anisantho-Artemisietum austriacae* Kostylev 1985

    4. *Convolvulo-Brometum inermis* Eliáš 1979

    5. *Calamagrostietum epigei* Kostylev in Solomakha et al. 1992

      var. *Dactylis glomerata*

      var. *Elymus repens*

    6. *Aristolochio-Convolvuletum arvensis* Ubrizsy 1967

Onopordetalia acanthii Br.-Bl. et Tx. ex Klika et Hadač 1944

  Dauco-Melilotion Görs et Rostanski et Gutte 1967

    7. *Berteroetum incanae* Sissingh et Tideman ex Sissingh 1950

    8. *Asclepiadetum syriacae* Láníková in Chytrý 2009

    9. *Echio-Verbascetum* Sissingh 1950

    10. *Melilotetum albo-officinalis* Sissingh 1950

  Onopordion acanthii Br.-Bl. et al. 1936

    11. *Potentillo argenteae-Artemisietum absinthii* Faliński 1965

    12. *Achilleo millefoliae-Grindelietum squarrosae* Kostylev in Solomakha et al. 1992

  Arction lappae Tx. 1937

    13. *Leonuro cardiacae-Ballotetum nigrae* Slavnić 1951

    14. *Arctio lappae-Artemisietum vulgaris* Oberd. ex Seybold et T. Müller 1972

DC *Arrhenatherum elatius* [*Artemisietea vulgaris-Molinio-Arrhenatheretea*]

Ecological preferences of the vegetation

The DCA-diagram (Fig. 2) reveals that the main environmental gradients of ecological ordination of the class *Artemisietea vulgaris* in the Kyiv urban area are thermoregime and light. The first axis reflects the division between relevés of open thermophilous and drought-adapted stands and vegetation of slightly shaded areas on quite moist soils.

According to ecological requirements, it has been found that within the Kyiv City the stands of *Artemisietea vulgaris* inhabit areas with insufficient moisture supply (Fig. 3A). Only *Medicagini lupulinae-Agropyretum repentis* tends to mesic conditions. The mentioned plant communities are also different in relation to other closely correlated edaphic factors, including soil aeration (Fig. 3B) and fluctuating water level (Fig. 3C). All phytocoenses of the class in the territory of Kyiv City prefer neutral soils (Fig. 3D) with a minimum content of mineral salts (Fig. 3E) and carbonate compounds (Fig. 3F). In

Table 2. **Values of Jaccard similarity coefficients for associations of the class *Artemisietea vulgaris* in the territory of Kyiv compared with other cities and regions of Ukraine**

Association	KR*	Chk	Mel	NBS	R
Convolvulo arvensis-Agropyretum repentis	0.05	0.23	0.16	0.09	0.23
Medicagini lupulinae-Agropyretum repentis	-	-	-	0.07	-
Anisantho-Artemisietum austriacae	0.33	0.02	0.05	0.09	-
Convolvulo-Brometum inermis	0.18	-	-	0.15	-
Calamagrostietum epigei	-	0.27	0.09	0.11	0.25
Berteroetum incanae	0.14	-	-	0.24	0.22
Melilotetum albo-officinalis	0.13	0.17	-	0.15	0.08
Potentillo argenteae-Artemisietum absinthii	0.10	-	-	-	0.19
Achilleo millefoliae-Grindelietum squarrosae	0.07	-	-	0.09	-
Arctio lappae-Artemisietum vulgaris	0.09	0.30	-	0.05	0.21

*KR — Kryvyi Rih (Yeremenko, 2017); Chk — Cherkasy (Osypenko, Shevchyk, 2001); Mel — Melitopol (Bredikhina, 2015); NBS — Northern Black Sea Region (Dubyna et al., 2004); R — Roztochya (Soroka, 2008).

terms of nitrogen content (Fig. 3G), it was observed that the stands belonging to the associations of the alliance *Arction lappae* are more demanding on such compounds compared to other communities of the *Artemisietea vulgaris*.

Differentiation of plant communities is not so pronounced according to climatic indicators. In relation to the thermal regime, stands of *Artemisietea vulgaris* are mainly submesothermic (Fig. 3H), subaridophytic according to the aridity-humidity of the climate (Fig. 3I), hemicontinental by its continentality degree (Fig. 3J), and hemicryophilic by cryoregime (Fig. 3K). It has been also found that phytocoenoses of the class are mostly distributed in open well-lit habitats (Fig. 3L).

Discussion

Based on the data analysis, we identified three orders, four alliances, 14 associations, and one derivative community within the class *Artemisietea vulgaris* in Kyiv City. In the territory of Kyiv, almost all types of phytocoenoses of the class *Artemisietea vulgaris* at the level of alliances are represented, except those described and distributed in Ukraine only in Crimea or in the adjacent continental southern part of the country (*Medicagini falcatae-Diplotaxion tenuifoliae* Levon 1997 and *Rorippo austriacae-Falcarion vulgaris* Levon 1997). It is necessary to emphasize that we have also included the alliance *Arction lappae* into the class *Artemisietea vulgaris*, despite its still debatable status. Our decision was based on the argument that the species composition of *Arction lappae* does not differ significantly from the vegetation of *Artemisietea vulgaris* class by prevailing in stands of its representatives, species of dry habitats and alien plants (both archaeophytes and neophytes). Since *Epilobietea angustifolii* (incl. *Galio-Urticetea*) vegetation is mesophilic and consists mainly of native species, we followed other European phytosociologists (Jarolímek et al., 1997; Borhidi, 2003; Matuszkiewicz, 2007; Chytrý et al., 2017) who classified nitrophilous biennial plant communities on mesic soils within the *Artemisietea vulgaris* class.

At the association level, vegetation diversity in the city of Kyiv represents 30.5% of the total diversity of the class *Artemisietea vulgaris* in the territory of Ukraine (Dubyna et al., 2019, 2022). Such significant syntaxonomic representation and comparison of this vegetation type with that in other large cities (Kucheryavyi et al., 1991; Yeremenko, 2017) allow us to conclude that within the study area the class *Artemisietea vulgaris* is characterized by high coenotic diversity. The diversity of man-made habitats as well as regional environmental conditions appeared as the most important factors affecting the variation in this vegetation type. Peculiarities of its vertical structure in the study area are manifested by dense species-rich stands, indistinct layer differentiation, and the high dominance ability of some diagnostic species. The coenotaxonomic specificity was manifested at the level of frequent species, which are characteristic of *Molinio-Arrhenatheretea*, *Koelerio-Corynephoretea canescentis*, and *Plantaginetea majoris*.

The species composition of most widespread associations is most similar to those reported for Central and Western Ukraine (Table 2), as well

Fig. 3. Distribution of associations of the class *Artemisietea vulgaris* by soil humidity (A), soil aeration (B), fluctuating of water level (C), soil acidity(D), salt regime of soil (E), carbonate content in soil (F), nitrogen content in soil (G), thermoregime of climate (H), ombroregime of climate (I), continentality degree of climate (J), cryoregime of climate (K), light regime of habitats (L). Numbers on the horizontal (x, abscissa) axis correspond to the number of syntaxa in the classification scheme, the values of environmental factors are indicated on the vertical (y, ordinate) axis, colours of boxplots indicate different vegetation alliances.

Continuation of **Fig. 3.**

as their habitat preferences. Primarily, due to the ruderal plants and typical species for neighboring grassland vegetation types of classes *Molinio-Arrhenatheretea*, *Koelerio-Corynephoretea canescentis*, and *Trifolio-Geranietea sanguinei*, those are more characteristic for the forest-steppe zone. At the same time, the species composition of the associations that are mainly distributed in the southern part of Ukraine in the study area includes more thermophilous plants than the same phytocoenoses in Central and Western Ukraine, if they were found there.

In the study area, vegetation of *Artemisietea vulgaris* follows and replaces the plant communities of annual ruderal vegetation of the class *Stellarietea mediae*. When further human impact is absent or insignificant, stands of *Artemisietea vulgaris* could be replaced by different types of herb or scrub vegetation depending on the initial environmental conditions. However, because of permanent human pressure within the territory of Kyiv City, stands of the class for a long time remain at the serial stage, without proceeding to the next stages of succession.

The leading factors of territorial differentiation of *Artemisietea vulgaris* within Kyiv City are the soil type and its structure, as well as the intensity of diverse human impact and habitat disturbances. We demonstrated that the vegetation of *Artemisietea vulgaris* is distributed throughout the entire city. It is typical for disturbed natural habitats, lawns, railway slopes, roadsides, waste places, industrial sites, and abandoned sports grounds. The most widespread stands within the territory of Kyiv City belong to the associations *Convolvulo arvensis-Agropyretum repentis*, *Medicagini lupulinae-Agropyretum repentis*, *Calamagrostietum epigei*, *Berteroetum incanae*, *Leonuro cardiacae-Ballotetum nigrae*, and *Arctio lappae-Artemisietum vulgaris*. We also observed active spread of some other plant communities. In particular, during our observation period the number of stands dominated by *Asclepias syriaca* has apparently increased. The plant is native to North America and within its native range it grows in well-drained sandy, clayey, or rocky calcareous soils along the banks of lakes, ponds, and waterways, in prairies, and at forest margins (Bhowmik, 1994; Hartzler, Buhler, 2000; Gudžinskas et al., 2021). In the study area, it most often occurs in dry habitats, particularly along roads and railways. We also found this species accompanied in the stands of unmanaged xeric and mesic grasslands of the city. Its tolerance to a wide range of soil humidity (from dry to moist soils), high potential ability to invade different habitats, as well as factors of climate changes, may facilitate its further spread over larger areas in the future (Gudžinskas et al., 2021). Climate changes also affected the appearance within the city of some plant communities typical for southern regions, e.g., *Anisantho-Artemisietum austriacae* and *Convolvulo-Brometum inermis*, which in the previous survey of the vegetation of Ukraine (Dubyna et al., 2019) were reported only for the steppe zone. The most habitable (suitable) areas for these plant communities in the study area are the open and driest sites near railway tracks and large roads. In such places, microclimatic indices correspond to those characteristic of the habitats of these stands.

Further research of the vegetation of the class in the territory of Kyiv City is desirable. There are some associations belonging to the class *Artemisietea vulgaris* that we expect to appear in Kyiv; first of all, those with the diagnostic participation of thermophilous species, as well as some alien ones. The presence of non-native plants in urban areas increases over time and now it causes significant changes in the composition and structure of the flora and plant communities of the city. It is therefore really important to contribute to the research on the trends of occurrence and spreading of alien species in various types of the *Artemisietea vulgaris* coenoses and, depending on the obtained data, start to develop the appropriate management measures to prevent biodiversity losses in neighboring natural vegetation types. In addition, habitats of *Artemisietea vulgaris* within Kyiv and other urban environments may be important for protection of certain endangered plant species.

Conclusions

The vegetation of the class *Artemesietea vulgaris* in Kyiv is characterized by high coenotic diversity. Based on the analysis of the representative dataset, we identified three orders, four alliances, 14 associations, and one derivative community. They prefer mostly man-made habitats and semi-natural sites with well-lit nutrient-rich soils, different regarding humidity and mechanical structure. Our ecological analysis reveals that the main environmental gradients of the ordination of the class *Artemisietea vulgaris* in the Kyiv urban area are thermoregime and light. According to ecological requirements, it has been found that the stands of *Artemisietea vulgaris* inhabit areas with insufficient moisture supply, neutral nutrient-rich soils with a minimum content of mineral salts and carbonate compounds. Peculiarities of the vertical structure of plant communities in the study area are manifested by dense species-rich stands, indistinct layer differentiation, and high dominance ability of some diagnostic species. The coenoses of the associations *Convolvulo arvensis-Agropyretum repentis*, *Medicagini lupulinae-Agropyretum repentis*, *Calamagrostietum epigei*, *Berteroetum incanae*, *Potentillo argenteae-Artemisietum absinthii*, *Leonuro cardiacae-Ballotetum nigrae*, and *Arctio lappae-Artemisietum vulgaris* are most widespread within the Kyiv urban area. The studies of the class in the territory of Kyiv should be continued, especially with regard to contributed data about introduction and further spreading of alien plant species in various types of *Artemisietea vulgaris* habitats and appearance of new vegetation associations, for developing the appropriate management measures.

Ethics Declaration

The authors declare no conflict of interest.

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Рудеральна рослинність міста Київ. I. Клас *Artemisietea vulgaris*

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Реферат. У статті, яка є продовженням серії публікацій з дослідження рудеральної рослинності м. Києва, представлено результати синтаксономічного вивчення рослинних угруповань класу *Artemisietea vulgaris.* Встановлено, що синтаксономічне різноманіття класу на території міста представлено 14 асоціаціями та одним дериватним угрупованням, які належать до 3 порядків та 4 союзів. Подані результати екологічного та ординаційного аналізів рослинності *Artemisietea vulgaris*, наведені синморфологічні особливості угруповань та охарактеризовані умови їхніх місцезростань. Встановлено, що рослинність класу *Artemisietea vulgaris* поширена на території всього міста. З’ясовано, що основними факторами екологічної диференціації угруповань класу *Artemisietea vulgaris* є терморежим та освітленість біотопів. Різноманіття антропогенних екотопів, а також особливості кліматичних умов регіону є визначальними у територіальному поширенні угруповань класу в межах міста. Проведені дослідження та їхні результати є важливими для стратегічного планування та практичного впровадження заходів зі збалансованого розвитку міста та оптимізації екологічних умов у межах міської агломерації.

Ключові слова: ординація, синтаксономія, Україна, урбоекосистема, фітоіндикація

MYCOLOGICAL RECORDS
МІКОЛОГІЧНІ ЗНАХІДКИ

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RESEARCH ARTICLE

The second record of a rare fungus *Flammulina ononidis* (*Physalacriaceae*) in Ukraine

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Abstract. The second record in Ukraine of a rare fungus *Flammulina ononidis* (*Physalacriaceae*, *Agaricales*) is reported. This species is known in 16 European countries but is rare in most of them. In Ukraine, it has not been found for more than 50 years. The article provides a complete description of the macro- and microscopic details of the collected fruit bodies, as well as distribution data. The differences from some related species are described and original illustrations of the fungus are provided.

Keywords: *Agaricales*, *Flammulina*, new record, *Ononis spinosa*

Introduction

Recently an interesting collection of a fungus apparently belonging to the genus *Flammulina* P. Karst. (*Physalacriaceae*, *Agaricales*) was recorded in Ukraine. The fruiting bodies were found in a pasture among various herbaceous plants, including dry remnants of *Ononis spinosa* L. The fungus was preliminary indentified as *Flammulina ononidis* Arnolds. Afterwards, the study of microscopic features of the collected fruiting bodies has confirmed this identification. This is a very remarkable find, because *F. ononidis* is a relatively rare species in Europe. It grows saprotrophycally on dry roots of *Ononis spinosa* (Arnolds, 1977; Ripková et al., 2008) and is currently known from 16 European countries. In most of them it is rather rare (reported from less than 10 locations): Austria — 7, Italy — 7, Czech Republic — 6, France — 4, Spain — 3, Croatia — 2, Switzerland — 2, Estonia — 1, Hungary — 1, Poland — 1, and Slovakia — 1 (Ripková et al., 2008; Mešić, 2019; GBIF..., 2022). An exception is Germany with about 40 reported localities (Mešić, 2019), though in the GBIF online database (GBIF..., 2022) only 17 localities are recorded for this country. The species is also included in *The IUCN Red List of Threatened Species* as Vulnerable (VU) (Mešić, 2019) and in the national fungal Red Lists of four European countries: Austria — Endangered (EN) (Dämon, Krisai-Greilhuber, 2016), Croatia — Vulnerable

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Fig. 1. Fruit bodies of *Flammulina ononidis* (KW-M71531). Bar — 1 cm

(VU) (Tkalčec et al., 2008), the Czech Republic — Critically Endangered (CR) (Holec, Beran, 2006), and Germany — Endangered (EN) (Dämmrich et al., 2016). As to Ukraine, *F. ononidis* was previously recorded only once, more than 50 years ago (Wasser, 1971). Unfortunately, its specimens have not been deposited in the herbarium and so cannot be investigated. Our collection represents the second locality of this rare fungus in our country and is worthwhile to be described more in details.

Materials and Methods

All macroscopic and microscopic features of the fungus are based on one collection. The microscopic structures were observed in dried material. Microscopic sections of lamellae were made at about ½ radius of the pileus, those of pileipellis were made near the margin of the pileus. Preparations were mounted and examined in 3% KOH. Spore sizes are based on at least 20 spore measurements per fruit body. For basidia, cystidia, and terminal cells of ixohyphidia, the statistics are based on 10 measurements per fruit body.

The following abbreviations are used in the description of spores: av. W = average width of the spores in frontal view; av. L = average length of the spores; Q = length/width ratio; av. Q = average Q. The following abbreviations are used in the description of fruit bodies: L = number of lamellae reaching stipe; l = number of short lamellae (not reaching stipe) between two long ones.

The specimen reported in the article is deposited in the Herbarium of the M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine, Kyiv, Ukraine (KW-M).

Results and Discussion

***Flammulina ononidis* Arnolds**, Westfälische Pilzbriefe 11(3-4): 33. 1977. — Figs. 1, 2.

Flammulina velutipes var. *pratensis* Schief., Z. Pilzk. 21: 21. 1949. — *Collybia velutipes* subsp. *pratensis* (Schief.) Schief., Z. Pilzk. 29: 109. 1963.

Fruit bodies collybioid. Pileus 0.5–3.0 cm in diameter, at first hemispheric, later convex to expanded, sometimes with low umbo in centre, viscid, honey yellow, pale orange to pale orange brown, in centre darker, up to orange brown, translucently striate at margin. Lamellae rather distant (L = 20–26; l = 1–3), adnate, yellowish white to pale ochraceous yellow. Stipe 1.5–4.5 × 0.1–0.3 cm, cylindrical or slightly tapering downwards, sometimes with root-like basis, velvety, pale yellowish at top, towards base darkening, orange brown, reddish brown to dark brown. Flesh in pileus whitish, up to 0.1 cm thick, in stipe pale yellowish at the top, downwards darkening up to dark brown at base. Taste mild, smell insignificant.

Spores (7.0–)8.0–11.5 × 4.0–4.5 μm (n = 60), av. L = 9.7 ± 1.24 μm, av. W = 4.7 ± 0.50 μm, Q = 1.70–2.30, av. Q = 2.08 ± 0.16, ellipsoid, narrowly-ellipsoid, cylindrical-ellipsoid, smooth, thin-walled, hyaline, inamyloid. Basidia 25.0–27.0 × 6.0–7.0 μm, narrowly-clavate, 4-spored. Cheilocystidia 40.0–70.0 × 9.5–12.0 μm (n = 30), narrowly-utriform to lageniform, apex 3.5–7.0 μm broad, thin-walled, hyaline, abundant. Pleurocystidia 40.0–60.0 × 8.0–12.0 μm (n = 30), similar to cheilocystidia, apex 5.0–8.5 μm broad, very scattered. Pileipellis an ixotrichoderm, consisting of ixohyphidia and rather numerous pileocystidia. Pileocystidia 45.0–110.0 × 8.0–10.5 μm (n = 30), narrowly-fusiform to narrowly-lageniform, apex 4.0–5.0 μm broad, rather thick-walled (up to 0.5 μm), brownish yellow. Ixohyphydia 1.0–1.5(–2.0) μm wide, thin-walled, hyaline; terminal cells of ixohyphidia 30.0–60.0 × 3.6–6.0 μm (n = 30), narrowly fusiform with mucronate tip, sometimes with slightly inflated medium part, usually branched, with 1–3 lateral branches (with mucronate tips too), as a rule with many constrictions along all length, thin-walled but in basal half with slightly thickened walls, hyaline. Stipitipellis consisting of parallel hyphae with numerous erect terminal cells, those 25.0–100.0 × 5.0–6.0 μm, with slightly narrowed tips, thick-walled, yellow-brown. Caulocystidia 50.0–85.0 × 9.5–11.5 μm (n = 30), rather numerous, fusiform, narrowly-fusiform to narrowly lageniform, apex 3.0–6.0 μm broad, rather thick-walled (up to 0.5 μm), brownish yellow. Hyphae in all tissues with clamp connections.

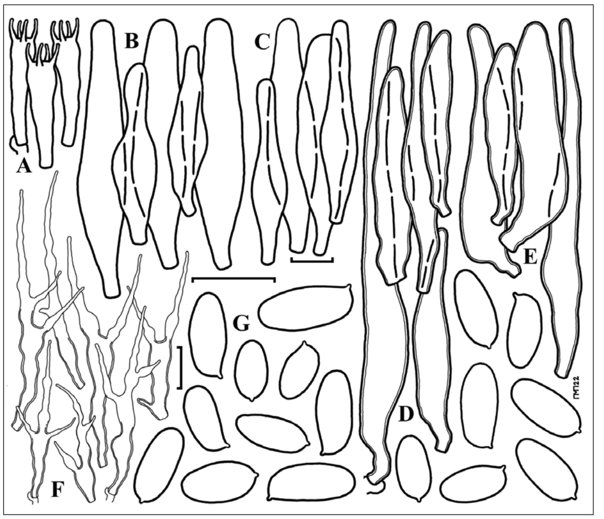

Fig. 2. Microscopical features of *Flammulina ononidis* (KW-M71531). A: basidia; B: cheilocystidia; C: pleurocystidia; D: pileocystidia; E: caulocystidia; F: terminal cells of ixohyphidia; G: spores. Bars — 10 μm

Fruit bodies grow solitary or in small groups (1–3 specimens), on dead roots and stem bases of *Ononis spinosa*, in pastures and meadows. According to literature data, it prefers calcareous soils (Arnolds, 1977; Klán, 1978; Vesterholt, 2012; Mešić, 2019). A rare species, up to date only two localilties have been found in Ukraine. May–November.

Specimen examined. *Zakarpatska* (Transcarpathian) Region, Rakhiv District, village of Chorna Tysa, pasture, N 48°17'26.7", E 24°22'14.6", 08.11.2022 (KW-M71531), coll. K.I. Fedorova.

Other known localities: *Kherson* Region, Kakhovka District, Askania-Nova Biosphere Reserve, arboretum, May–November 1968, coll. S.P. Wasser (Wasser, 1971, as *Flammulina velutipes* var. *pratensis*).

General distribution. Europe: Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Poland, Russian Federation, Slovakia, Spain, Switzerland, Ukraine. Asia: Turkey (Ripková et al., 2008; Mešić, 2019; GBIF..., 2022).

One of main distinctive macromorphological features of *Flammulina ononidis* is its pseudorhiza, solitary (or in small groups) growth (not in large clusters), and connection to remnants (mainly roots) of herbaceous plant *Ononis spinosa*. Another European species with similar peculiarities is *F. cephalariae* Pérez-Butrón & Fern.-Vic. which grows on roots of *Cephalaria leucantha* (L.) Roem. & Schult. in Spain (Pérez-Butrón, Ferdnández-Vicente, 2007). A rather important distinctive sign of both species is also their habitat, namely seminatural grasslands, while other representatives of the genus prefer wood habitats, both natural and anthropogenic.

Microscopically *Flammulina ononidis* differs from most representatives of the genus by rather large spores (over 8.0 µm long and over 4.0 µm wide). *Flammulina cephalariae* and *F. rossica* Redhead & R. H. Petersen have also large spores, particularly *F. cephalariae* possessing spores 12.0–17.0 µm long (Ripková et al., 2010), while spores of the second species are rather similar to those of *F. ononidis.* However, *F. rossica* can be separated by the form of the prevailing type of terminal cells of ixohyphidia, which have distinct central or terminal globose inflation up to 9.0 µm wide and 1–3 lateral nodules or short branches (not mucronate as ones of *F. ononidis*) (Adamčík, Ripková, 2008). Besides, *Flammulina rossica* is a lignicolous species (Adamčík, Ripková, 2008; Ripková et al., 2010). Spores of similar length are also reported for *F. elastica* (Sacc.) Redhead & R.H. Petersen, but they are distinctly narrower (as a rule up to 4.0 µm wide) (Ripková et al., 2008, 2010).

It is worth mentioning that various authors provide rather different information about the size of spores of *Flammulina ononidis*. Their data vary from (7.5–)8.1–10.1(–10.7) × 4.1–5.0(–5.2) µm (Ripková et al., 2010) to (7.5–)8.5–13.0(–14.0) × (4.0–)4.5–6.0 µm (Pérez-Butrón, Ferdnández-Vicente, 2007). The spores of our specimens of *Flammulina ononidis* were most similar to the data of Arnolds (1977): (7.5–)8.5–11.0 × (4.0–)4.5–5.5(–6.0) µm.

Flammulina ononidis is probably a very rare fungus both in Ukraine and in Europe. Its suitable habitats, semi-natural grasslands, still occupy rather large territories in Ukraine but their areas gradually decrease (National..., 2018). They are very dependent on traditional agricultural practices, namely grazing by large herbivorous animals (cattle, horses, sheep, etc.) as well as regular mowing. During later decades these traditional agricultural practices are constantly declining in our country, and that is also a general European trend. In absence of grazing and mowing, grasslands become gradually overgrown by shrubs and trees and thus become unsuitable for many native fungi, including *F. ononidis*. It is one of the main threats for the fungus both in Europe and in Ukraine. Another large peril is intensification of agriculture (increasing in Ukraine) which also destroys suitable habitats by replacing them with monoculture fields. In Ukraine, still an additional factor exists. The previous Ukrainian record of *F. ononidis* is located within a territory currently occupied by the Russian Federation and can potentially be destroyed at the scene of war. The consequences of this destruction for natural habitats are very difficult to predict. Taking into account the fact that up to now *F. ononidis* has been recorded in Ukraine only twice and the above mentioned threats for it, the fungus has to be considered as a candidate for inclusion in the *Red Data Book of Ukraine*.

Ethics Declaration

The authors declare no conflict of interest.

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Друга в Україні знахідка рідкісного гриба *Flammulina ononidis* (*Physalacriaceae*)

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Реферат. Повідомляється про другу в Україні знахідку рідкісного гриба *Flammulina ononidis* (*Physalacriaceae*, *Agaricales*). Цей вид трапляється в 16 європейських країнах, але є рідкісним у більшості з них. В Україні його не знаходили понад 50 років. У статті наведений детальний опис макро- та мікроскопічних деталей будови зібраних плодових тіл та надана інформація про розповсюдження цього гриба. Описані його відмінності від споріднених видів і подані оригінальні ілюстрації цього гриба.

Ключові слова: нова знахідка, *Agaricales*, *Flammulina*, *Ononis spinosa*

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